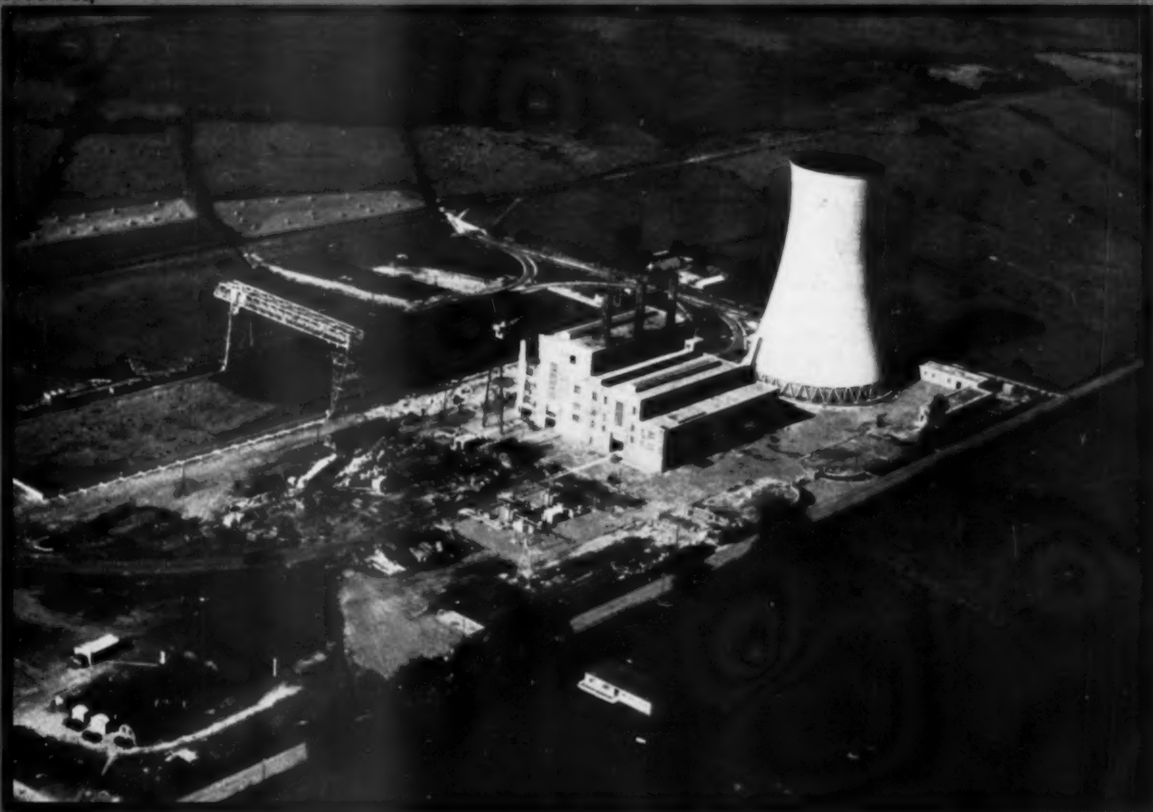
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

August, 1950



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August, 1950

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Editorials

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COMBUSTION

Editorials

Smoke Abatement in New York

As we go to press, hearings are being conducted on the proposed rules for controlling smoke in New York City. Briefly, they define *dense smoke* as that which cannot be seen through at the point of emission. This is prohibited, except for a period not exceeding four minutes when cleaning fires or firing a cold boiler. Permissible dust emission from stacks, except during cleaning periods, ranges from 0.8 to 2.2 pounds per thousand pounds of steam, depending on size of installation. A maximum of twenty-four per cent volatile in the fuel is prescribed. Permits for construction and operation and the filing of plans would be necessary for new installations or alterations, except as concerns standard domestic equipment; and where approval is conditional upon test, the expense is to be borne by the owner.

The hearings have revealed objections to specific limitations on fuels on the ground that with proper equipment and operation it is possible to exceed such limits without causing a nuisance and, further, that in the event of war much of the coal that would meet the prescribed restrictions would likely be unavailable in the New York market. Again, it was pointed out that the definition of dense smoke is subject to individual interpretations; that the cost of making tests to secure approval should not be borne by the owner, but regarded as an expense incident to policing the ordinance. Finally, it was suggested that an independent Appeals Board would be preferable to having appeals made to the Smoke Control Board, which is the enforcement body.

The crux of the problem is avoidance of objectionable smoke and fly-ash discharge. If this end result can be accomplished through proper design and operation, the means should not be encumbered by restrictions.

The World Power Conference

The Fourth World Power Conference, held last month in London and reported in this and next months' issues, was the first such meeting in fourteen years, the war having interrupted the regular schedule of holding a Plenary Meeting every six years. In the interim since the Third Conference at Washington in 1936, world events have done much to change and disrupt the power situation; hence the present was a fitting time to take stock, as expressed by the Conference theme—"World Energy Resources and the Production of Power."

The importance of power in the economic progress and well-being of nations is now appreciated more than ever, and the contributions of over a hundred and fifty papers by representatives from forty-seven countries afford an invaluable background and reference, especially since technological developments transcend political boundaries.

The present Conference differed from the 1936 meeting in two respects—one of which was most commendable by its subordination and the other which might profitably have been included. It may be recalled that an unfortunate note of discord was introduced into some of the general sessions at Washington by inclusion, at the insistence of certain representatives of our government, of controversial public ownership topics. This was wisely avoided at London. However, the 1936 Conference supplemented its general meeting at Washington by a series of Round Table Conferences on selected topics, in different sections of the country, at which operating problems and experiences were open for discussion. Such discussions were profitable and might well have supplemented the current excellent papers on energy resources and design practice in various countries.

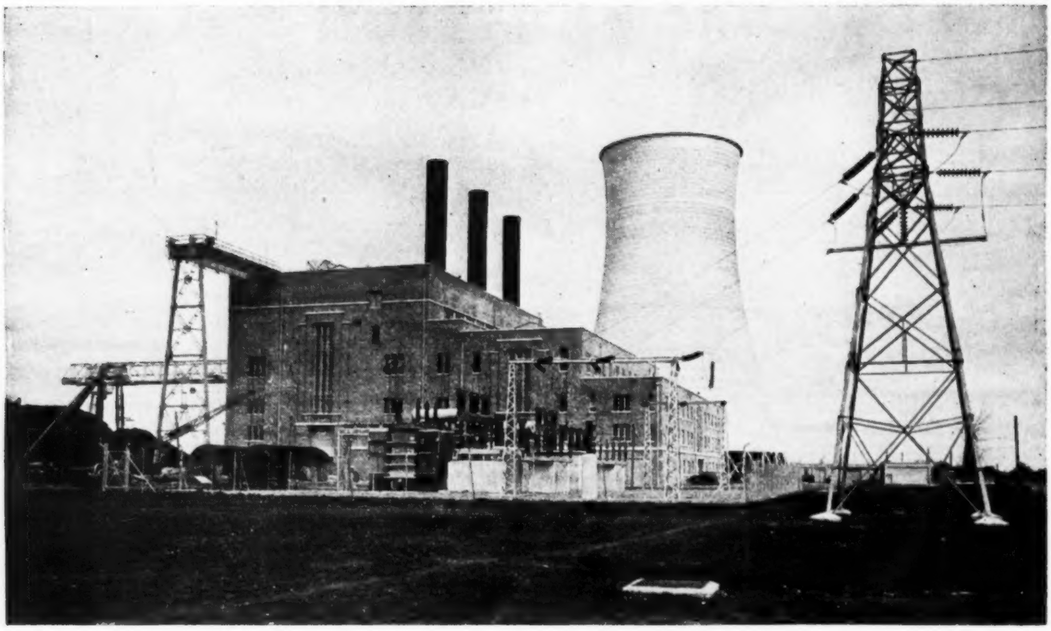
A National Water Policy

"National Water Policy—A Statement of Desirable Policy with Respect to the Conservation, Development and Use of the National Water Resources" is the title of a report recently prepared by the Water Policy Panel of the Engineers Joint Council and submitted on July 1 to President Truman's temporary Water Resources Policy Commission. In view of the fact that as late as May of this year Congress authorized projects for river resource development involving a potential total cost approaching two billion dollars, there should be no doubt of the need for a comprehensive, workable, overall national water policy. This is especially true in the face of overlapping of functions and the lack of purposeful coordination of activities that has marked the work of the several Federal agencies concerned.

By reason of its prestige as a clearing house for five national societies representing civil, mining and metallurgical, mechanical, electrical and chemical engineers, the Engineers Joint Council was able to call upon the services of about seventy-five leading engineers to serve on voluntary task committees responsible for developing a statement of a desirable water resources policy.

The report points out that during the past two decades there has been a marked decline in the standards applied to deciding whether or not certain projects should be constructed. It adds that although all benefits from national undertakings are not easily converted to quantitative terms, it is essential that wherever possible measurable financial values be attached to projects. Intangible benefits may have significance, but they must be explicitly identified and considered separately from items that can be expressed in monetary terms.

The EJC has rendered a major service by its sponsorship of this searching, objective report.



General view of Portarlington Station; note huge cooling tower

Power from Peat in New Irish Station

By W. CRONIN*

PEAT, or turf as it is called in Ireland, is a combustible material formed by the humification of plants under certain conditions, and in its natural state it contains about 95 per cent moisture. It is mainly composed of vegetable matter together with the decomposition products of the original plant substances. To obtain a commercial fuel, it is necessary to reduce the moisture content to between 20 and 40 per cent, which was one of the biggest problems in the economical development of the fuel. For centuries past, peat has been made available for domestic use by methods that have not changed through the years, but in order to produce it in sufficient quantities for power station use, machinery for draining the bogs and winning the peat had to be developed. Irish engineers tackled this problem in a most enthusiastic manner, and now all the operations associated with the production of peat are completely mechanized.

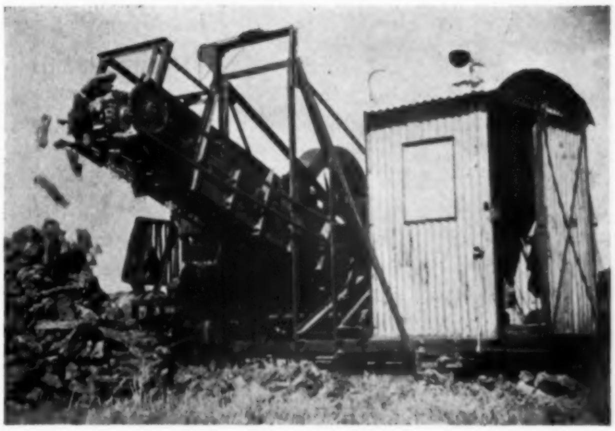
Before any bog can be developed, a detailed survey has to be made to determine how much bog area in depth is available for development, the quality of the peat and the drainage conditions. To drain a bog, several miles of closely spaced drains have to be made, and the time taken to complete drainage operations varies from four to six years. Drains are usually cut to a depth of about 12 ft and are about 2 ft wide at the bottom. The bog drain-cutting machines are each capable of cutting about six miles of drains in a season. Two further operations have then to be completed, namely, stripping and leveling. The stripping machine, by means of a chain of knives of special design, removes a width of about 12 ft from the shoulder of the drain and piles the spoil on the off side of the machine. The leveling machine has a chain of knives 24 ft wide which spread the spoil across the bog and in this way depressions are filled in and the general unevenness removed. The surface of the bog is now ready for production to commence.

Methods of Preparing Peat

There are two methods of preparing peat, either in sod form or as milled peat. In Ireland for power station use, it is being developed in sod form and for manufacture into briquettes in milled form. The peat-cutting machine consists of a continuous bucket excavator, a macerating unit and a chain conveyor to spread the sods, fixed at right angles to the motion of the machine. The complete unit, which weighs about 40 tons, is mounted on caterpillar tracks. These machines cut, macerate and spread the sods automatically.

Each machine has a crew of six men, which operates on three shifts continuously during the summer season. During this period each machine can produce about 20,000 tons of peat. They are electrically driven by two motors, a 40-kw and a 25-kw at 550 volts, supplied from a trailing cable. The large motor drives the macerator and the spreader forward drive, and the smaller motor drives the caterpillars and a number of small screw conveyors. The machine travels at a speed of about 50 ft per hour. A bog area of 600 acres is required for each machine. In operation, the raw peat from the excavating buckets is delivered by a conveyor to the macerator. The macerated peat is then delivered

* Station Superintendent, Electricity Supply Board, Dublin.



View of sod collector

through a double orifice on to a chain conveyor, from which the sods are tipped off onto the bog surface.

The peat is then air dried to about 30 per cent moisture and the sods are built into reeks, (mounds), from which the fuel is loaded into rail trucks and conveyed to its destination.

Preliminary Boiler Design Problems

From the point of view of the use of peat as a boiler fuel, its main characteristics are:

(*a*) Proximate analysis of dried peat—fixed carbon 30 to 40 per cent, volatiles 55 to 70 per cent, ash 2 to 10 per cent.
(*b*) Average net calorific value at 30-per cent moisture is 6000 Bth per lb.
(*c*) Fusion point of the ash is about 1150 C.

It is, therefore, necessary in the design of the combustion chamber to provide a pre-drying shaft to reduce the moisture content to approximately 15 per cent and to provide a large furnace volume owing to the low fusion point of the ash. Furthermore, since peat has approximately half of the calorific value of coal and twice the volume for the same weight, it is necessary, in order to keep the stoker area within reasonable dimensions, to design the stoker to operate on a fuel bed thickness of from 15 to 30 in.

For small industrial plants, peat gas producers are being developed, and in the course of this process sulfate of ammonia and other valuable by-products can be removed. Experiments are also being conducted in the utilization of peat for operating gas turbines, although there are many design problems yet to be overcome. It is not possible here to go into details of the many ways in which the fuel will ultimately be utilized, but the immediate aim is to use it for the generation of steam in power stations.

The station at Portarlington is erected on the bank of the River Barrow, on a site of about 30 acres. The boiler plant, turbine-generators, control room and general offices are in the main building, and on the right-hand side a hyperbolic cooling tower is situated. At the back of the boiler house is the fuel storage which is capable of holding 40,000 tons, and is spanned by a bridge crane. The railway line from the bog circles the fuel storage, and there are also rail connections to the main line system.

The peat is delivered directly from the bog in specially designed trucks, each of 5 tons capacity. On arrival at the station, it is weighed and samples are taken for analysis. It can then be directly unloaded into the boiler bunkers or to the fuel storage for future use. For unloading, special cranes are provided, one bridge crane over the storage and two over the boiler bunkers. The cranes are designed to lift a truck off the bogie wheels, carry it to the required area, and tilt the truck so as to allow a hinged door to open and discharge the peat. The truck is then returned to its bogie. Both diesel and peat-burning locomotives are used for hauling the trucks.

Steam Generating Units

In the boiler house are installed three 150,000-lb per hr B. & W. boilers, operating at 425 psi, with a final temperature of 825 F, the steam temperature being controlled by means of an attemperator. The heating surface of each boiler is 10,000 sq ft, and the superheater surface is 5830 sq ft. The side walls of the combustion chamber are of Bailey construction, and the front and rear walls are constructed of refractory material. Each boiler is equipped with twin stokers, having a total width of 29 ft and length of 22 ft, driven by variable-speed motors. Each boiler has a tubular air heater and a steaming economizer of flash-welded construction.

From the bunker the peat passes through a pre-drying shaft, through which hot air is blown in order to reduce the moisture content of the fuel, and at the bottom of which is incorporated an ignition grate, so that combustion takes place before the fuel reaches the traveling stoker. The fuel bed thickness is varied by two water-cooled fire doors, and a special design of fork door is provided above the drying shaft to step the fuel prior to banking or shutting down. The ash which falls into hoppers, is mechanically crushed and is removed by a suction ash-disposal plant into a large hopper which cools the ash, and discharges into railway cars for removal from the station. The average ash content of the fuel is about 2.5 per cent and the carbon content of the final ash 0.5 per cent.

The draft equipment was supplied by Messrs. Davidson & Co. Ltd., Belfast. Each boiler has a double-inlet, radial-tipped-blade induced-draft fan driven through a

Main excavating portion of stripping machine

variable-speed hydraulic coupling by a 330-hp motor at 735 rpm. There are two forced-draft fans driven through hydraulic couplings by a 105-hp motor at 970 rpm and two secondary air fans driven by 45-hp motors. Both the induced- and forced-draft fans are located over the boilers and each boiler has a self-supporting steel stack.

The boiler-control panel is situated in the center of the firing floor. It is of the totally enclosed cubicle type with desk, which contains the remote controls for the motors and hydraulic couplings. The principal instruments for each boiler are a six-point draft gage, a ten-point thermo-electric pyrometer to measure water, air, gas, and steam temperature, feedwater meters, CO_2 recorders, and a number of direct-reading temperature and pressure instruments.

A chemical plant is provided to treat the makeup water from the river, which contains about 250 ppm total hardness. Provision is also made for conditioning the boiler feedwater with caustic soda and sodium sulfate, and pumps are provided for the injection of phosphate solution direct to each drum. There is also a recirculating pump on each boiler, which circulates some of the salines from the drum into the economizer inlet.

There is a fully equipped laboratory in which the complete chemical analysis of the fuel is determined. The laboratory staff is also responsible for the control of the water treatment and for the testing of lubricating and transformer oils.

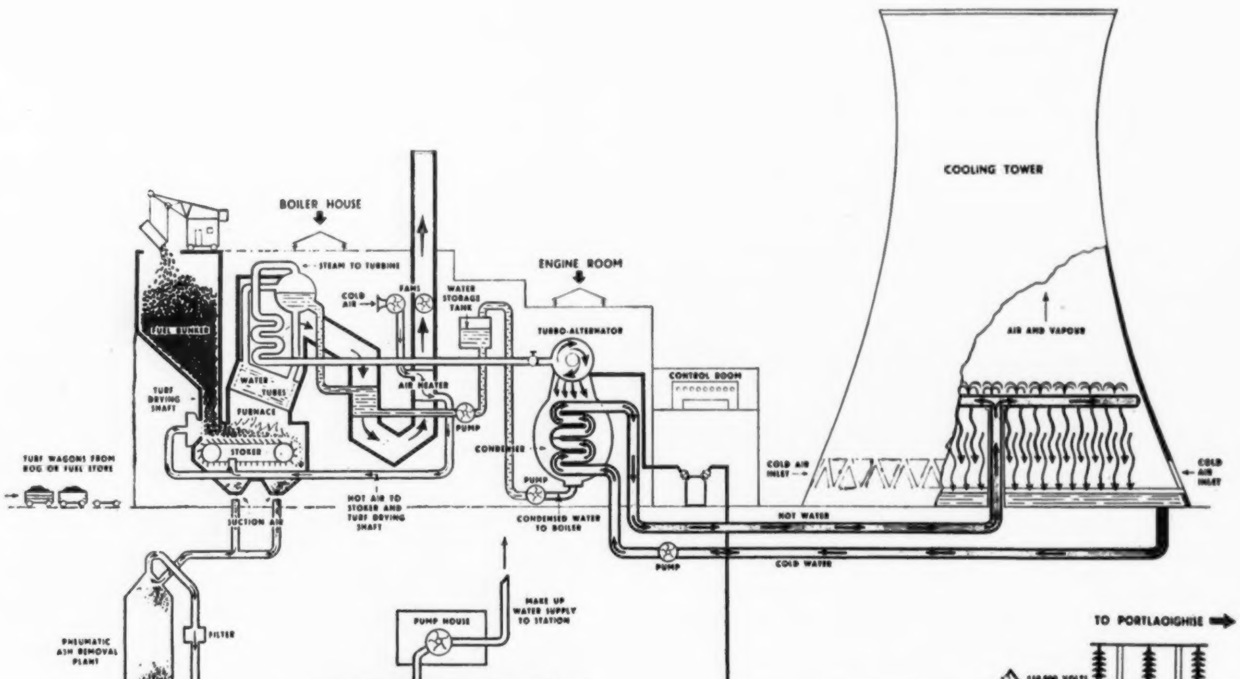
The boiler feed pumps are located in the turbine room. Two are electrically driven and one steam-turbine driven. The last mentioned is designed to start up automatically in the event of low feedwater pressure. Each pump has a capacity of 250,000 lb/hr at 590 psi when running at a speed of 2900 rpm. Boiler water level is controlled by Copes regulators.

Turbine-Generators

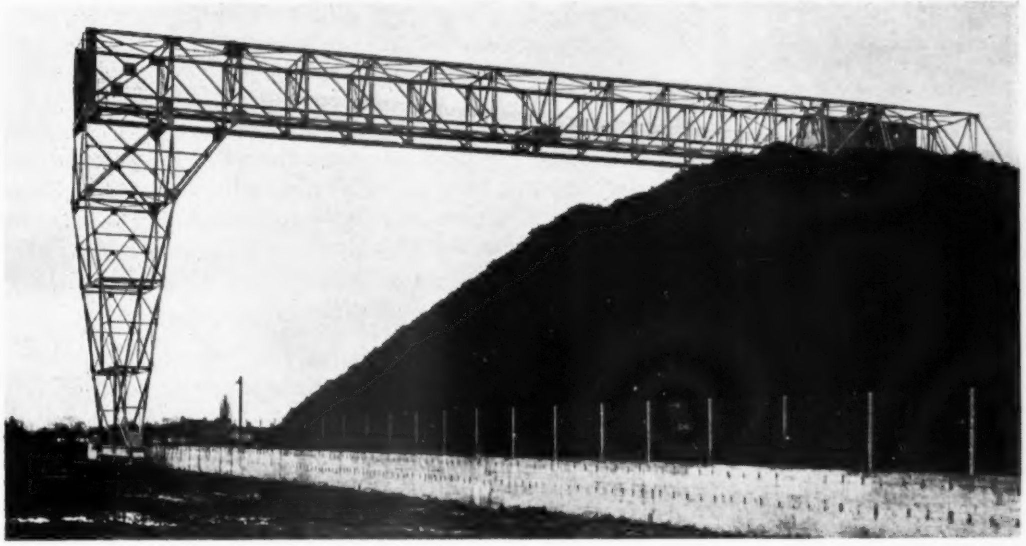
The generating plant consists of two 15,600-kw turbine-generators, of the Ljungstrom type, which were supplied by A.S.E.A. Electric Ltd., London, and manufactured in Sweden. They are double-rotation radial-flow machines, and have one axial stage. In this type of turbine the radial blades of one wheel act as guide blades for those of the other; consequently there are no fixed guide blades. These turbines can be run up to full speed in about ten minutes. Three-stage heating is employed, the condensate being heated to a final temperature of 270 F. The most economical load on the turbine is 12,500 kw, the steam consumption at this load being 9.25 lb per kw hr.

Each turbine exhausts into a two-pass condenser of 17,200 sq ft surface. The quantity of cooling water required for each turbine is 12,500 gal per minute, which is circulated through a cooling tower, 236 ft high and 176 ft at the base. Approximately one per cent of the circulating water is lost by evaporation in the tower and this is replaced by water pumped from the river. The makeup water is continuously chlorinated, the chlorinator automatically changing over to a new drum of chlorine when the one in use empties. The rate of the chlorine dose is automatically regulated in accordance with the rate of makeup. Provision is also made for the addition of Calgon to the makeup water so as to prevent scale forming in the condenser tubes.

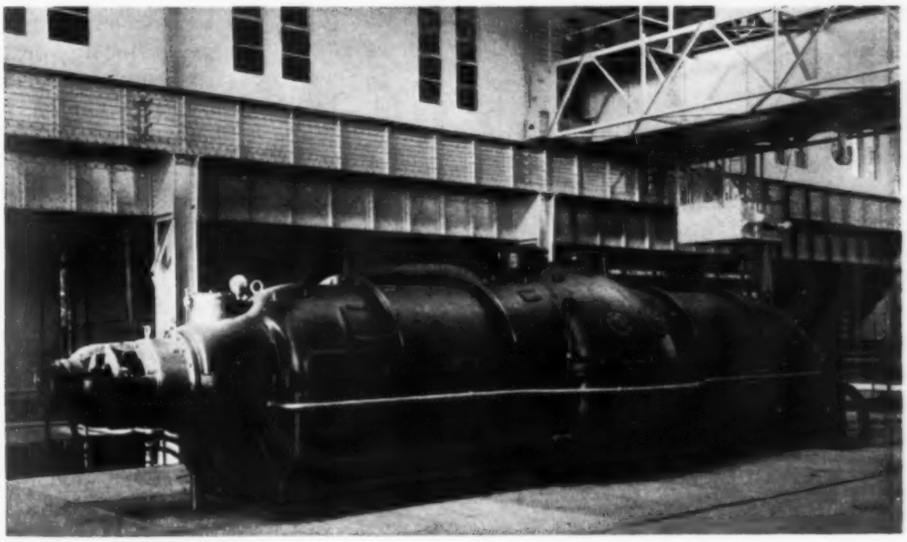
Each turbine has two generators designed to operate at 10,000 volts, 3 phase, 50 cycles with direct-connected main and pilot exciters. The voltage regulation is controlled by a Brown Boveri automatic regulator. Generator protection consists of over-current and over-voltage protection, interturn stator-winding and field-winding



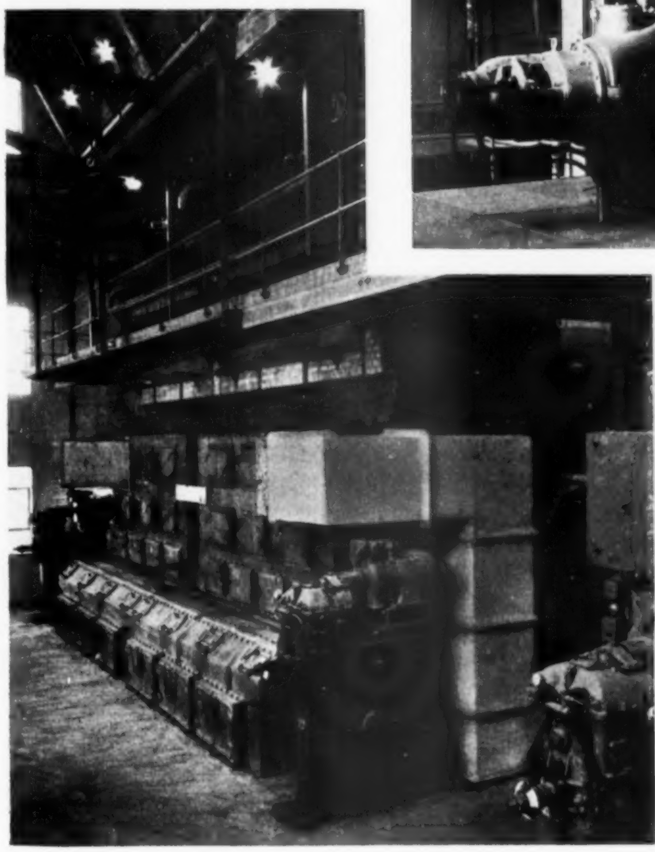
Schematic diagram of Portarlington Station (Courtesy of Electricity Supply Board)



Fuel-storage area served by bridge crane



One of two 15,000-kw radial-flow Ljungstrom turbine-generators



Boiler front showing drying shaft

Main control room

protection, together with differential current, reverse power and earth-fault protection. All the relays, except the over-current relay, trip the steam stop valve and the field switch. The over-current relay trips the main circuit-breaker only, so that the set is available for load as soon as the fault has been cleared. It is also arranged that when the stop valve shuts, the vacuum in the condenser is broken and this insures that the turbine rotors will come to rest quickly.

Electrical Features

Output from the generators is taken through low oil-type motor-operated circuit-breakers to the 10-kv busbars. The house supply is taken from two 2000-kva transformers and all the motors are supplied at 380 volts. Outside the main building there are situated two 20,000-kva tap-changing transformers which raise the voltage from 10 kv to 110 kv, and are connected to the main grid system.

The main control room is situated on the same level as the turbine floor and from it all the high-tension and low-tension switch gear is controlled. It contains all the indicating and protection relays for the sets. The control room operator can establish direct contact with all the other stations by means of a high frequency telephone which operates over the main 110-kv transmission lines.

Station Performance and Costs

Cost of construction of the station was approximately £1,280,000, ($3,584,000). The cost of peat at 30 per cent moisture is 39/6*d* per ton ($5.53) and the estimated fuel consumption per kilowatt-hour generated is 3 lb, so that the cost of fuel per kilowatt-hour is 0.635 pence (0.741 cent) and the total production costs, including interest, depreciation and maintenance, are estimated at 1.028 pence (1.2 cents) per kwhr.

The actual fuel consumption during the past four months has been 2.6 lb per kwhr which is a reduction of 0.4 lb from the estimated figure. Provided that the price of a ton of peat is about half the price of coal which has to be imported, it is as economical to generate from peat as from coal, with the advantage that the development of the bogs is giving a considerable amount of employment both to skilled and unskilled workers.

Two more peat-fired stations are in the course of construction, one at Allenwood, County Kildare, and another at Ferbane, County Offaly. Each of these will have a capacity of 40,000 kw.

Operation of the Portarlington Station during the past few months has been very satisfactory and no difficulty has been experienced in maintaining the normal boiler loading. It was designed and construction supervised by the engineering staff of the Electricity Supply Board (Ireland), and the principal contractors were as follows:

Boiler plant	Babcock & Wilcox, Ltd., London
Turbine sets, transformers and switch-gear	A.S.E.A. Electric Ltd., London
Structural steelwork	Chapman & Co., Belfast
Building and cooling tower	Irish Engineering & Harbour Construction Co., Dublin
Peat store and turbine-room crane	Sir William Arrol, Ltd., Glasgow
Boiler-house cranes	Oerlikon, Ltd., London

WORLD POWER CONFERENCE—I

A digest of the papers on energy resources and power developments of the various participating countries, also those dealing with the preparation of solid, liquid, gaseous and synthetic fuels. The second part of this report, to appear in the September issue, will deal with the production of power from different sources, current practice in power plant design, including boilers, steam turbines, gas turbines, internal-combustion engines and hydro units. Views on power from nuclear energy will be included.

APPROXIMATELY 160 papers were presented by representatives of twenty-seven countries at the Fourth World Power Conference held in London, July 10–15, inclusive. These divided into three main groups, namely: (1) energy resources and power developments as reported by the national committees of the participating countries; (2) the preparation and burning of solid, liquid and gaseous fuels; and (3) production of power by steam engines and turbines, internal-combustion engines, gas turbines, hydro, nuclear fission, wind, solar energy, etc.

Before reporting some of the high spots of these various papers, it may be of interest to some COMBUSTION readers to review very briefly the background of the World Power Conference.

The idea for such an organization was conceived by a well-known British engineer, the late Daniel N. Dunlap, founder and director of the British Electrical and Allied Manufacturers Association. Largely through his efforts the First World Power Conference was held at Wembley England, in June 1924. This proved so successful that a permanent international organization was formed to plan Plenary Conferences every six years and Sectional Meetings on specific topics in interim years. The Second World Power Conference was held in Berlin in 1930 and the Third in Washington in 1936. World War II interrupted the schedule until the present conference in London. The following Sectional Meetings took place: 1926 at Basle with water power and inland navigation as the theme; 1928 at London to consider fuels; Barcelona in 1928 to discuss water resources; Tokyo in 1929 to take up various aspects of power production and utilization; 1933 at Stockholm and 1938 at Vienna. A post-war Sectional Meeting devoted to fuel economy was held at The Hague in 1947.

"Energy Resources and Power Developments" comprised the first group of twenty-six papers at the current conference covering conditions in countries containing some 40 per cent of the world's population.

Scandinavian Countries

Starting with northern Europe, **Norway,** which has practically no fuel resources excepting some coal in the far northern island of Spitzbergen, reported a doubling of its developed water power capacity to nearly three million kilowatts during the last 25 years. This represents a present available all-year capacity of 1,895,000 kw, which is roughly 16 per cent of the potential hydro power of that country. Less than one per cent of the electricity generated comes from fuel. Peat has long been used in certain coastal regions, but wood is the most common fuel for domestic heating in rural districts. Of the total present electric-energy production, about 41 per cent is utilized for electrochemical and electrothermal industries, 22 per cent for other industries, $1^1/_2$ per cent for electric railways and the remainder for domestic, commercial and agricultural uses.

In **Sweden** there is little coal and its quality is relatively poor; nor are there any petroleum resources. The main dependence for electric energy is water power, only about 7 per cent being produced by steam. The present installed hydro capacity is approximately 2,675,000 kw, which represents an increase of $3^1/_2$ times during the past 25 years and about one-third of the estimated potential capacity. A construction program recently initiated will bring this figure to 55 per cent by 1955. Inasmuch as the principal water-power sites are located in the North and the bulk of electricity requirements are in the South, long-distance transmission is necessitated.

In **Finland** about two-thirds of the electricity supply is generated by water power, with the remainder divided about equally between condensing and back-pressure turbines, steam for which is produced by imported fuel. Difficulties caused by the cession of certain territories to Russia after the war involved the loss of considerable developed water power; hence a construction program was initiated and is now under way involving twelve developments of 390,000 kw aggregate capacity.

Denmark has only insignificant natural-energy resources. Inability to import fuel during the war brought about radical changes in the normal production of power involving the exploitation of lignite and peat, supplemented by limited amounts of coal from Germany. Immediately following the war, however, the electricity supply was reorganized on a rational basis involving an interconnected system served by eleven large central stations of 981,000 kw aggregate capacity with 628,000 kw new capacity to be available by 1952. This centralizing of electric production is expected to effect large savings in imported fuel. The only location for establishing a combined electric generating and district heating plant is in Copenhagen where such a station will be in service in 1952.

British Isles

Great Britain has very few natural fuel and power resources other than coal, the reserves of which have been variously estimated as adequate for 100 to 200 years.

In the last 25 years, electric generating capacity has increased $3^1/_2$ times and output 8 times.

Eire, according to the Irish National Committee, has only a small amount of coal which is mostly anthracite, a limited amount of water power, and a substantial amount of peat, of which some 3,600,000 tons are harvested and burned yearly for electric generation and domestic use. Two additional peat-fired central stations of considerable capacity are now being erected by the Electricity Supply Board. Installed hydro capacity aggregates 178,000 kw from developments on the Shannon, Erne and Liffey Rivers.

Western Europe

Of the 65 million tons of coal that **France** needs annually, she produces about 45 per cent, the remainder being imported. About half the annual production of electricity is by water power. There are no oil fields within the boundaries of France, but she participates in the production of Iranian oil which accounts for an important refinery industry. Sources of natural gas produce only about 6360 million cubic feet per year. Present new construction is based on the assumption that electricity demand will double in 10 years.

The **Netherlands** depends primarily upon coal, with only small water-power potentialities. Natural gas borings in the eastern section show promise. Electricity consumption has increased rapidly in the last few years and new steam plants are being built.

A similar condition prevails in **Belgium.**

The principal power resources of **Portugal** are hydro, about three-fourths of which is concentrated in the northern part of the country and thus necessitates an extensive transmission system. However, fluctuations in rainfall have made it necessary to supplement the hydro capacity with about 30 per cent steam power, the greater part of the fuel for which is imported, as the domestic solid fuels are mostly poor-quality anthracite, lignites and brown coal, all of high ash content. Liquid fuels have not been found.

Central Europe

In central Europe, **Switzerland** depends mostly upon water power as there is a favorable balance between summer and winter flow. Fuel-burning plants constitute only 6 to 7 per cent of the total capacity, and their output is less than 2 per cent of the total. Although consumption of electricity has trebled in the last 25 years, much of the energy is exported. Wood is of considerable importance as a domestic fuel.

Austria has some resources of brown coal, but imports two-thirds of her solid fuel requirements. Her principal internal source of energy is water power, although at present only about an eighth of her water-power resources have been developed. Uneven seasonal availability of the hydro power has made necessary the installation of steam plants, also interconnection with Germany. During the last 25 years hydro capacity has expanded fivefold and thermal generating capacity has doubled.

Hungary has important bituminous coal and brown coal resources which supply about 94 per cent of her present electrical requirements. She possesses important oil fields of sufficient yield not only to meet domestic demands, but also to permit export. There is also considerable natural gas. Although hydro energy has thus far played only a minor rôle, substantial developments on the Danube and Tizza River systems are contemplated.

Czechoslovakia possesses coals of varying qualities, also brown coal and lignite. There are considerable quantities of excellent coking coal, as well as gas coal, a large part of which is consumed in the metallurgical industry. The brown coal and lignites are employed mostly for heating in industry and for domestic use, although considerable development has been going on during the last decade in the production of synthetic fuels and gas from the brown coal. Very little hydro power is available because of the scarcity of high head streams. Such water power as has been developed is largely on rivers. Energy production was nationalized in 1945.

Southern Europe

In **Italy**, where the present construction program is approaching completion, over 80 per cent of the economically useful resources will have been developed and the fuel-burning capacity greatly augmented, although fuel for the latter must be imported. An important contribution to Italy's fuel economy are the geothermic generating stations utilizing steam from the earth. These plants are being expanded. Some natural gas is also available.

Yugoslavia has no large coal deposits but substantial resources of brown coal and lignite, oil shales, crude petroleum and natural gas. She also has water-power potentialities which, however, have not yet been developed on a large scale. A considerable program of expansion of both steam and hydro capacity is in hand.

The energy resources of **Greece** are water power and lignites. Although potential water power is sufficient to produce about $4^1/_4$ billion kilowatt-hours per year, only a small fraction has been developed.

Africa

Across the Mediterranean in Africa, **Egypt** is without coal and practically all her power requirements are produced from oil. Some hydro power will be available from the Aswan Dam, and at a later date development of the upper Nile will considerably augment the supply of electricity.

Algeria reported progress in coal mining to the extent of 226,000 metric tons in 1948. Hydro output in 1949 was 145,000,000 kwhr, which is expected to increase to 325,000,000 by 1952.

Coal is by far the largest source of electric energy in the **Union of South Africa,** which has neither oil nor natural gas and only a few small hydro plants, as rainfall is seasonal and facilities for economical water storage are lacking. The coal is not of high calorific value but is abundant and relatively cheap at the pithead. The main problem in locating new steam power stations is available condensing water.

India

The energy resources of **India** are limited to coal and water power. Workable coal reserves are estimated at approximately 15,000,000,000 tons, of which about a fifth are at present being worked. The annual coal out-

put in 1948 was 30 million tons. Although a comprehensive survey of potential water power has not yet been undertaken, the estimated figure is about 25 million kilowatts. To date only about half a million kilowatts of hydro power has been developed. The total installed capacity in public utility steam stations, using coal, is about 800,000 kw, in addition to which industrial power plants account for 600,000 kw. These figures apply to India after partition.

The Antipodes

The Australian National Committee reported on the energy resources and power developments in **Australia** and the territories of **Papua** and **New Guinea.** These resources are confined mostly to solid fuels and hydro power, although some shale oil is produced in **New South Wales.** The coal reserves of extractable anthracite and bituminous coal in Australia are estimated at 14 billion long tons with an average calorific value of about 11,500 Btu per lb. In addition there are an estimated 39 billion long tons of subbituminous coals, brown coals and lignites having a calorific value of around 4000 Btu per lb. Some wood is also used in energy production. The total water power resources of the Australian Commonwealth, developed and undeveloped, amount to around 2,300,000 kw, of which approximately 80 per cent is concentrated in **Tasmania.**

South America

The only South American committee reporting was that of **Chile,** which has total proved reserves of over 61 million metric tons of good bituminous coal (14,400–15,200 Btu per lb) out of a total estimated reserve of 698 million metric tons. This coal is found in both submarine and subterranean seams.

Petroleum was discovered near Magellan Straits in 1945 with indications that these resources in two principal fields amount to a total of some 35 million barrels.

The water-power resources of Chile are large and are estimated at about 7 to 8 million kilowatts. The installed generator capacity per capita is 1.21 kw, and the consumption per capita in 1948 was 1170 kwhr per year. As there is a shortage of power in that country, a program of water-power development by means of state-owned plants is being carried out.

North America

Canada has extensive sources of energy in its known reserves of coal, oil and natural gas, but much the greater amount of the energy used is derived from its large water-power developments aggregating approximately 8,300,000 kw, which is about 20 per cent of the total-estimated resources.

Although there is an abundance of coal of all qualities, ranging from low-grade lignites to high-grade bituminous and semi-anthracite, development of Canada's coal fields has progressed slowly because of their locations relative to present concentrations of industry and population.

Production of oil in Canada has been continuous since its discovery in Ontario in 1860. The provinces in which are now located commercial oil fields are New Brunswick, Ontario, Saskatchewan, Alberta and the Northwest Territories. About 90 per cent of the present total Canadian oil production comes from Alberta, where there are also large gas reserves.

According to the latest available figures covering 1948, fuel-generated electricity in Canada then accounted for only 2.8 per cent of the total. However, new large steam-power plants are now under construction to carry peak loads in Ontario. A feature of electrical production in Canada has been the sale of off-peak secondary power at reduced rates for steam raising in electric boilers which in pre-war years absorbed about 25 per cent of the total output.

The **United States** National Committee reported that coal continues to be the largest single source of energy. Annual oil production has trebled in the last 25 years and during the same period there has been a four-fold increase in the output of natural gas which now supplies more than 10 per cent of the national energy consumption. Proved reserves of oil and gas have increased to a greater extent than the output, and known reserves of oil in the form of oil shale are four to five times greater than those of oil recovered by present methods.

Estimates of potential water-power resources have more than doubled in the last 20 years and only about 16 per cent of the estimated total has so far been developed.

Coal Preparation

A number of papers were presented on the preparation of solid fuels, covering coal, lignite, brown coal, peat and coke, as practiced in various countries. In general, with the growth in use of cutting and loading machines, there has been an increase in the fines and dust which are more difficult and costly to clean. In some instances in the **United States,** as mentioned in a paper by Morrow and Hebley, measures have been taken at the face to minimize these effects and thus lighten the coal-preparation problem.

The ash content of **French** run-of-mine coals varies between 25 and 35 per cent, with coal from the largest field, the Pas-de-Calais Nord, having the highest ash content. The majority of washeries there are old and the average ash content of washed coal runs about 10 per cent.

In **Great Britain** there is diminishing popularity of the dry cleaner, due to its inability to cope with the increased moisture content of run-of-mine coals resulting from the widespread adoption of water for dust suppression.

Dealing with the situation in **Canada,** E. Swartzman, pointed out that the increased demand for cleaner and more uniform coals has run parallel with the growth of mechanization, and expansion of cleaning facilities, especially in eastern Canada, have become imperative. In that section, which is responsible for about 37 per cent of the total output, only about 20 per cent of the coal mined is cleaned. In the past it was feasible, by selective mining, to produce coal suitable for industrial and railway use; but conditions have now changed, as exemplified by rising production costs and the adoption of mechanization. To meet this problem wet cleaning is favored, although it becomes necessary to dry the product to prevent freezing in winter. It has long been necessary to clean about 80 per cent of the coals of western Canada, jig washers being employed in most cases.

In **Belgium** the five-year program of electric-power reorganization is nearing completion. It is based on a total of 800,000 kw and about two-thirds of the boilers will be pulverized-coal-fired. The available coal is variable and of poor quality, and in order to obtain the desired flexibility many of the new installations are equipped with the bin system. Those that are direct-fired employ either bowl mills or impact mills.

Preparation and Utilization of Lignite, Brown Coal and Peat

Of the six papers under this heading three dealt with brown coal and lignite and three with peat. All these fuels have high moisture content, the brown coal and lignite ranging up to 65 per cent and the peat up to as high as 93 per cent. In some cases the brown coal and lignite run high in ash, but the peat seldom contains more than a small percentage.

In **Czechoslovakia** and **Yugoslavia** the brown coals and lignites are usually devoid of caking properties. The hard variety, found in north Bohemia and Slovakia has a calorific value, as mined, of 11,700 Btu per lb and can be cleaned to an ash content of 1.5 per cent with a resultant calorific value of 14,000 Btu per lb. Besides being used directly as a solid fuel, it is also utilized for the production of synthesis gas which, in turn, is converted to liquid fuels.

Owing to the limited available quantity of high quality solid fuels in Yugoslavia, lignite must be used despite its poor quality with about 50 per cent moisture, 10 to 15 per cent ash and a calorific value of only 3600 Btu per lb. An added disadvantage is that it breaks down into small sizes on air drying. In order to render it transportable it has been processed by drying with steam under pressure or in a drum dryer employing hot waste gases from the boiler. Also, low-temperature carbonization has been applied in some cases to produce a semi-coke of 10,800 to 12,600 Btu per lb, but the product has limited application because of the excessive proportion of small sizes.

With the object of increasing the usefulness of these low-grade fuels as a source of steam making, a special technique termed "ignition from below" has been used.

As for peat, one paper described the practice of preparing and utilizing it in Ireland; another told of Swedish practice; and a third its use in Denmark.

In **Ireland** electrically operated dredgers excavate the wet peat which is air dried to 30 per cent moisture before utilization. The bog area per machine is 700 acres with an average life of 31 to 33 years and is capable of producing about 20,000 tons of air-dried peat.

In **Sweden** a state company has undertaken the production of 50,000 tons of briquettes per annum from milled peat. These briquettes contain 10 per cent moisture and have a calorific value of 7380 Btu per lb. They are easy to transport and do not disintegrate on burning.

In **Denmark** dry-kneaded peat represents 45 per cent of the annual production, wet-kneaded peat 35 per cent, hand-cut peat 5 per cent and milled and raked peat 15 per cent. Special attention must be given to storing to avoid spontaneous combustion, although the risk is less if the peat is of uniform quality and free from fines. If so, it can be safely stacked to a height of 23 ft. This height can be slightly exceeded with milled peat from well-humified bogs. However, it is not contemplated that peat will be extensively used for power generation in Denmark while bituminous coal and oil can be imported. Instead, it appears to be the policy to conserve the rather limited reserves to meet emergencies.

Preparation of Liquid Fuels

Papers under this general heading included several on petroleum refining, processing and utilization; the production of oil from shale; synthetic fuels; and coal-tar products.

Of particular interest was one by Messrs. Schroeder and Fieldner, of the **U. S. Bureau of Mines,** reporting its research and demonstration plant work on oil shale and coal as commercial sources for liquid fuels. For this purpose three laboratories were erected and put in operation; the first near Pittsburgh to study processes for producing liquid fuels from coal; the second, at Morgantown, W. Va., to develop economical methods for producing synthesis gas from coal; and the third, at Laramie, Wyo., for oil-shale research. Also, an oil-shale demonstration mine and pilot plant producing 50 to 100 bbl per day has been in operation since 1947 at Rifle, Colo.; and at Louisiana, Mo., a 200-bbl per day hydrogenation demonstration plant is now going into operation. A modified Fischer-Tropsch demonstration plant of 80 bbl per day will be completed early next year.

In addition to this government activity a number of private companies are carrying on research and experimental work.

Based upon experimental work conducted thus far, the authors estimate that commercial hydrogenation will be able to produce gasoline at 10 to 11.3 cents per gallon, depending upon the coal used. Comparable costs are estimated for the Fischer-Tropsch process, and 8.4 cents per U. S. gallon of gasoline, heating oil and diesel oil by commercial shale oil plants.

Several other papers discussed advances in petroleum refining both in Europe and America, and a paper by Messrs. Williams, Wilson and Martin, of the **British National Committee,** reviewed the use of petroleum fuels for the production of power particularly the increasing demand for the so-called "middle distillate" fractions as used in diesel engines, gas turbines, for domestic heating, etc. They submitted evidence that the heavier oils can be used for such applications and urged that manufacturers of power-plant equipment seek to design their products to use a wider range of fuels so as to insure the greatest overall economy.

Gaseous Fuels

Natural gas is playing an increasing rôle in the fuel supplies of the **United States,** its contribution to the total energy supplies having increased from 10.7 per cent in 1937 to 13.3 per cent in 1947; and they are still further increasing. The gross production of natural gas in the United States in 1948 is given as six trillion cubic feet. Its expanding use has resulted in the rapid growth of pipe lines which totaled 240,000 miles in 1948.

Peak load demands are often met to some extent by providing underground storage in depleted wells, by

high-pressure storage in pipe batteries, or by storage in liquid form; although the usual way of handling variation in demand for some uses, such as boiler fuel, is to contract on an interruptible basis with stand-by fuel available. In this way some of the pipe lines have been enabled to operate with annual load factors in excess of 90 per cent.

In **Italy** the output of natural gas has increased steadily and reached over 7 billion cubic feet in 1949 through exploitation of deposits in the Po Valley. Heretofore the gas has been used mainly for steam raising and steelmaking and to some extent as bottled gas. It is now proposed to build a 120,000-kw steam station at Tavazzano in order to consume a large quantity of natural gas near its source. A second project is to utilize the gas near the point of production to manufacture synthetic ammonia which, in turn, will enter into the manufacture of fertilizers.

In **France** natural gas is produced mainly in the southwest, where the Saint Marcel field was discovered in 1939 and developed three years later. After being treated in the Boussens natural gasoline plant, the gas is distributed to consumers through a 500-mile pipeline system. Its main uses are for town gas manufacture or replacement, as well as for furnace and boiler fuel, the manufacture of fertilizer and as motor fuel. Its use is estimated to represent a yearly saving of 420,000 tons of coal and 82,000 tons of gasoline, propane and butane.

Discussion

Mr. Fieldner of the United States delegation pointed out that in this country a state of change is taking place from coal to oil and natural gas for power generation, and that gas lines now extend from Texas to New England. Nevertheless, coal represents 85 per cent of the presently known energy reserves of the country.

A member from France stated that wind power and tidal power are there being exploited and that water-power production has been practically doubled since the last Conference. The French also have an atomic pile.

An Austrian delegate pointed out that coal reserves in that country are very small, hence its economy is based largely on hydro power; that is, approximately 80 per cent of the total power is supplied by water and 20 per cent is thermal.

A member from Italy cited figures indicating that the potential hydro power of that country is around 5 million kilowatts and geothermal power 2 million. New steam plants are planned using natural gas as fuel, and a new aspect of the power economy in Italy is the use of steam plants for continuous operation rather than as stand-by.

One British engineer stated that their coal reserves are calculated to last only 150 years at the present rate of consumption and suggested that ten million tons per year could be saved by railroad electrification.

Another member from Great Britain expressed the opinion that tidal-power development might prove important, although it likely would be handicapped by the cost of transmission to the metropolitan centers of use.

In the session on liquid fuels a French delegate stated that although France is engaged in the production of oil from shale the yield is poor compared with that in the United States. He mentioned further that the direct burning of shale under boilers had been attempted; also that France has pilot plants operating on the Fischer-Tropsch process.

Commenting on the Fischer-Tropsch process, a British engineer revealed that studies had indicated it to be uneconomical in Great Britain and he questioned whether the increasing plant costs for such a process would not also render it less attractive in the United States.

In reply to this discussion Mr. Schroeder (U. S.) observed that the cost of obtaining fuel from natural petroleum is also increasing. In 1949 alone 40,000 wells had been drilled, representing 26,000 miles of drilling. He said one reason for the optimism of the U. S. Bureau of Mines was that operation of the pilot plants had indicated a greater yield than had been expected, due largely to the employment of automatic controls. Plants of 30,000 bbl per day had been planned in order to keep the production cost down. However, he pointed out that oil shale is more favorable than coal as a source of oil at the present time, and that the Union Oil Company has developed a satisfactory process which will produce 60-per cent jet fuel and 40-per cent diesel fuel.

(*Continued in the September Issue*)

Factors in Hot-Process Softener Design and Operation

A review of factors involved in the design of hot-process softeners, particularly those factors having to do with chemical reactions and the separation of solids from the treated water. The effect of temperature on the rate of reaction is explained and curves, based on research data, are included. The three basic types of hot-process units are compared.

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THE hot-process softener is a chemical-reaction unit for treating boiler feedwater with chemicals at elevated temperature, usually employing available exhaust steam, in order to reduce dissolved and suspended impurities to safe low values. Generally speaking, it is an extremely versatile unit, capable of treating raw waters of wide ranges of composition and producing an effluent which meets present-day stringent requirements for minimum concentrations of hardness, silica, oxygen, alkalinity and dissolved solids in the feedwater makeup.

There are three groups of factors which must be considered in the design of hot-process softeners:

1. Those which affect quality and uniformity of chemical results and efficiency and completeness of the chemical reactions.
2. Those which affect the effectiveness of hydraulic separation of solids from the treated water and determine its clarity.
3. Factors of mechanical design, control and instrumentation, which influence the foolproof, dependable operation of the equipment.

It is the purpose of this article to deal mainly with the first two groups.

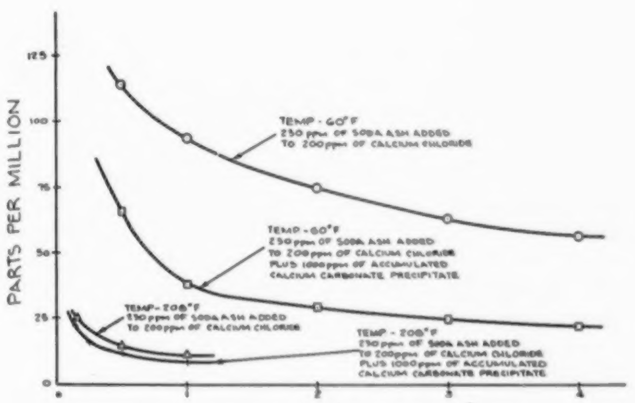


Fig. 1—Effect of temperature and contact with solids on speed of chemical reaction of calcium carbonate (all ppm values expressed as $CaCo_3$)

Factors Influencing Chemical Results

The factors which influence the chemical results obtained with hot-process equipment are:

1. Temperature of reaction.
2. Time of reaction.
3. Concentration of excess reacting chemicals.
4. Degree of mixing and turbulence in the reaction unit.
5. Contact with accumulated solids.

The effect of each of these factors has been thoroughly investigated in the laboratory, and equipment design has been modified and improved over the past forty years in order to accommodate the practical applications of these basic scientific principles.

Temperature of Reaction

The effect of heat on rate of softening or chemical reactions in general is well known. A rough rule is that the rate at which chemicals react in the usual lime-soda precipitation reactions is doubled for every 18 deg F rise in temperature. However, the relative effect diminishes as the temperature is raised.

From purely theoretical and empirical considerations, the Arrhenius equation,

$$\frac{d \ln k}{dT} = \frac{A}{RT^2}$$

expresses the relation between the specific reaction velocity k and temperature. In this equation, ln is the natural logarithm, T is absolute temperature, R is the gas-law constant, and A an energy-quantity characteristic of the reaction which is commonly the energy of activation. The value of A is generally determined empirically by measurement of the reaction-velocity constants at two temperatures.

Increased mobility of the ions and reduced viscosity of the water at elevated temperatures both markedly affect the speed of reaction. Laboratory chemical tests have clearly shown the effect of heat in accelerating the reactions forming calcium carbonate and magnesium hydroxide at high and at low temperatures. Fig. 1 (ref. 9) shows results obtained in laboratory beaker tests when precipitating $CaCO_3$ from solution by mixing $CaCl_2$ with Na_2CO_3 at temperatures of 60 F and 208 F. Also, the effect of mixing soda ash and water with accumulated $CaCO_3$ precipitate is shown. These data indicate the following:

(*a*) Increasing the temperature from 60 F to 208 F has a marked effect on reducing the residual concentration of $CaCO_3$ in the treated water for a given time period. At 208 F, residual hardness is reduced to less than 25 ppm in less than 15 min.

(*b*) With 60 F water, the addition of accumulated solids with the raw water and chemicals reduces the residual hardness to low values in much shorter time than without the contact with solids.

(*c*) With 208 F water, the addition of accumulated solids with the raw water and chemicals does not have appreciable effect in reducing dissolved residual hardness in the treated water.

These results confirm what operating experience showed long ago namely, that it is important to raise the water temperature in the hot-process softener to the very highest value, i.e., the same temperature as the exhaust or available steam in order to obtain the lowest hardness in the effluent. In practice, this is done by use of specially designed spray valves.

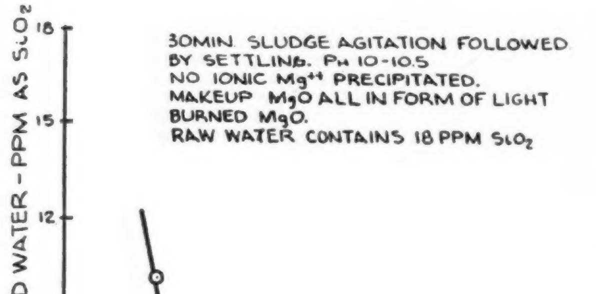


Fig. 2—Effect of temperature on silica removal by means of makeup and accumulated MgO compounds

Another important function of a hot-process softener is to reduce silica in the feedwater by means of reaction with fresh or previously accumulated magnesium hydrate compounds. High temperature and maximum degree of contact with high concentrations of magnesium hydrate compounds are absolutely essential in reducing silica efficiently in the hot-process softener.

The effect of temperature in this silica removal reaction is shown in Fig. 2. These laboratory data indicate that silica is much more effectively and quickly reduced when the temperature of the water, makeup MgO and accumulated MgO sludge is increased from 68 F up to 208 F. Indications are that the silica removal reaction is not one of adsorption but rather compound formation.

It is important to bear in mind that the viscosity of water at 68 F is approximately one centipoise while at 208 F it is 0.29 centipoise. This is a drop in viscosity of more than 70 per cent due to the temperature increase. This decrease reduces the frictional force of the water sliding upward past the solid particles and also influences the speed of motion of ions in solution.

Time of Reaction

By virtue of the increased speed and mobility of the ions involved, plus the decrease in water viscosity, chemical reactions are completed in much shorter time at elevated temperatures. This is clearly shown in Fig. 1 where the data for 208 F indicate that the chemical reaction forming calcium carbonate is more than 90 per cent completed in less than 10 min and virtually fully completed in 15 min. The presence of 1000 ppm of $CaCO_3$ precipitates in the mixture does not appreciably influence reaction time at 208 F.

Conservative hot-process unit design is usually based on 45 to 70 min. total retention time with filters following the hot-process unit and 70–100 min where filters are not required. This is usually measured by computing total retention in the tank from top water level to bottom straight.

In general, there are three basic hot-process unit types now in commercial operation. These are shown in Fig. 3. With downcomer Type S unit designs an additional 10 to 15 min. of retention time is obtained by extending the downcomer into the bottom cone. Therefore, for a given tank diameter, straight height and cone design, Type S units provide more retention by making active use of the bottom cone, over the F or U types of conventional units indicated in Fig. 3.

Excess of Chemicals Required

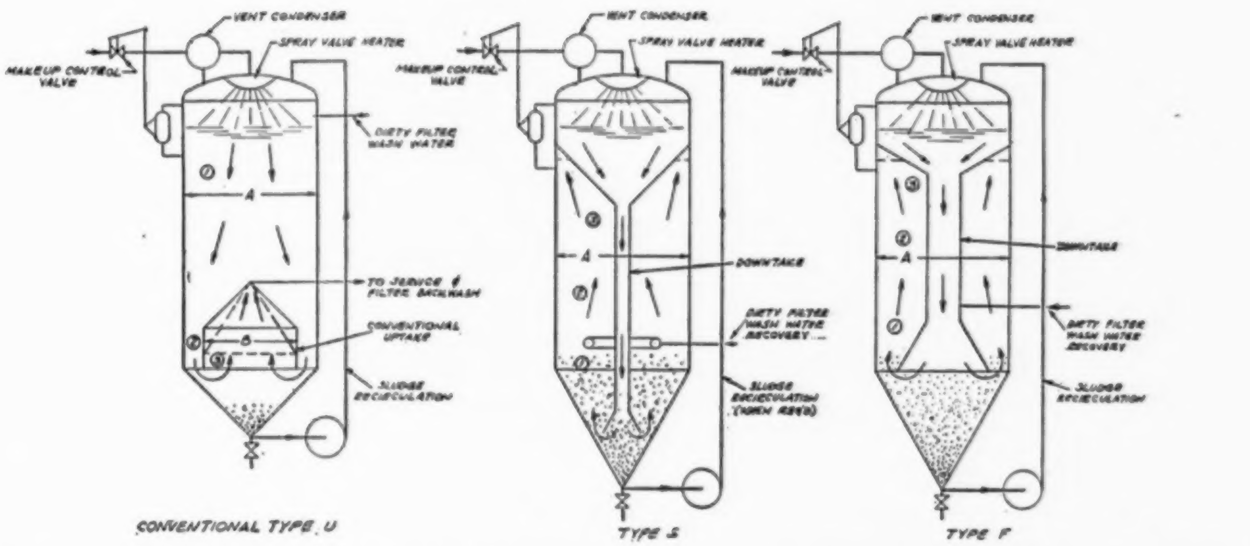
Fig. 4 indicates the relationship between residual hardness and excess soda ash in a well-designed hot-process softener. Without excess causticity, magnesium is reduced to less than 5 ppm, and calcium to less than 10 ppm providing about 25 ppm of excess soda ash is present, all as $CaCO_3$.

Experience has shown that the amount of excess chemicals required to obtain a given residual dissolved hardness is only slightly affected by the presence of large quantities of accumulated solids in the reaction. Apparently the main factor in determining the efficiency of chemical reaction and the excess required is the high temperature of the water.

Turbulence and Mixing

Turbulence and proper mixing is absolutely necessary if best results are to be had with hot-process treatment, but mechanical agitation is not usually required as with cold-process applications. The reason lies in the low viscosity of the water and the fact that mobility of the cations and anions in solution is from 20 to 40 times as great in water above 212 F compared with water at 60 F.

Where chemicals and sludge from a sludge recirculation pump are added to the water in a large 25- or 30-ft diameter conventional unit with U type conical uptake collector, as in the sketch, Fig. 3, some mechanical agitation is required and has been practiced for best results. This is because more than 40 min of retention time is consumed in a relatively quiescent zone and in a unit of large area.



Settling area B approximates 50 to 65 per cent of A. Velocity of water at point 3 is about three times that at 1

Settling area surrounding uptake is 90 to 95 per cent of area A and upward velocities of water at 1,2 and 3 are low, permitting separation of any fine turbidity remaining after contact with sludge bed. For a given tank area A, Types "S" and "F" provide approximately double settling area or half the upward velocity or upward settling rate of a conventional "U" type unit.

Fig. 3—Three basic hot-process unit types

However, with S and F type units of the downcomer design sufficient turbulence is created by combination of the water spray from the valves onto the top water surface plus the high velocity in the central downcomer pipe. This has been proved by operating experience with large unit designs (ref. 7).

Contact with Accumulated Solids

Contrary to cold-process operating experience, the effect of high concentrations of accumulated solid precipitates in contact simultaneously with the heated water and chemicals, on the hardness reduction, is not appreciable although some benefit is obtained. This is shown in the curves in Fig. 1 which indicate that there is no significant reduction in residual hardness due to the presence of 1000 ppm of solid calcium carbonate precipitate together with chemicals and water as compared to absence of solid precipitates in the laboratory beaker tests at 208 F, whereas there was considerable benefit at 60 F. This result has been confirmed in practice on large hot-process units employing such contact with recirculation of sludge (2 to 6 per cent by weight) up to 5 per cent of inlet flow. For this reason, contact with solids provided by sludge recirculation is not always employed for improved hardness reduction or increased chemical reaction efficiency.

Laboratory tests have also indicated that contact of incoming heated water and chemicals with accumulated solids does not appreciably increase the average size or density of the particles formed from the chemical reactions. The most pervasive factor in increasing particle size appears to be high temperature which permits maximum size particles to be formed rapidly.

In practice, sludge recirculation and introduction of solids into the top inlet is frequently practiced to assure freedom from precipitate formation in chemical feed lines and these solids also aid in increasing chemical reaction efficiency and rapidity as well as improving the silica removal.

In contrast, the effectiveness of silica reduction through contact with magnesium hydrate compounds is directly related to the concentration of magnesium hydrate precipitates brought into contact with the water being treated. This is shown in the curves in Fig. 5 (ref. 10). For minimum magnesium oxide makeup, it is desirable to maintain the highest concentration of solid magnesium hydrate compounds (usually above 200 ppm MgO) in contact with the water being treated. In practice, such contact with solids for optimum silica reduction is maintained by two methods, namely:

1. By recirculation of accumulated solids containing magnesium hydrate precipitate from the bottom cone through a pump and up into the top inlet of the softener where chemicals, makeup MgO and heated raw water also enter the unit(ref. 8). The concentrations of solid

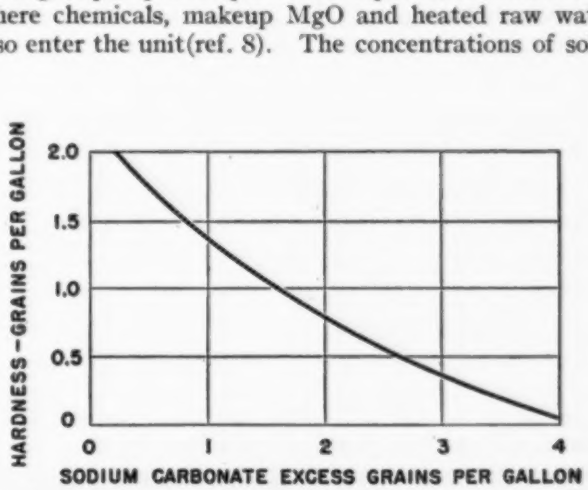


Fig. 4—Relationship of residual hardness to excess sodium carbonate

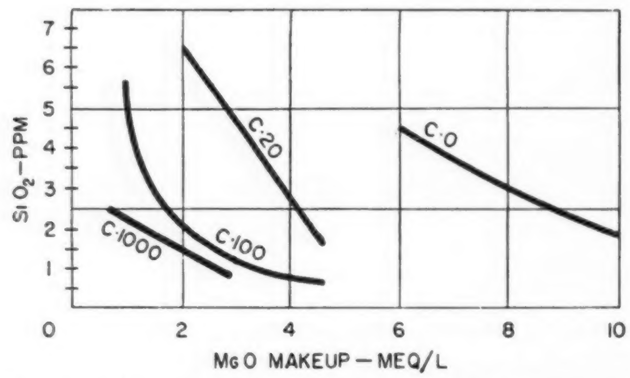


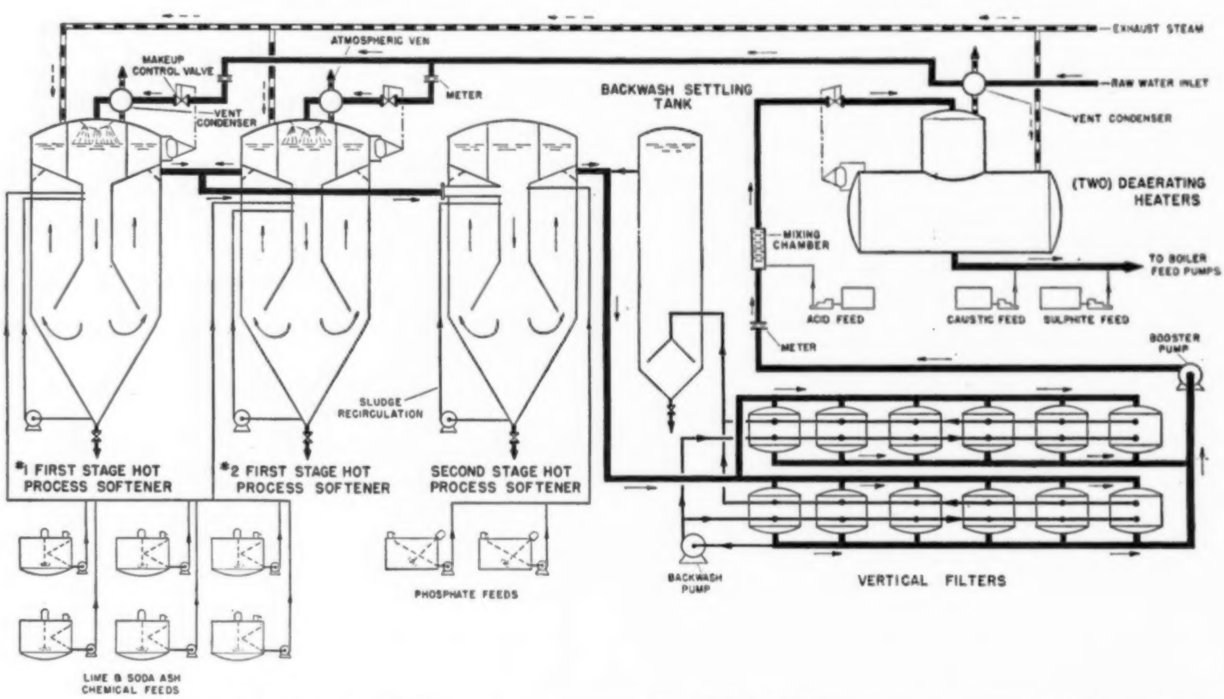
Fig. 5—Effect of contact with accumulated magnesium compounds at boiling temperatures

magnesium hydrate precipitates in the water economically and practically obtained with this method, including high magnesium oxide makeup requirements, are 200 to 600 ppm (as MgO). Fig. 6 is a flow sheet and influent and effluent analysis of a typical Graver 1,000,000-lb per hr, Type F hot-process installation employing sludge recirculation for silica reduction. Such recirculation is also employed with U type and, in some cases, with S unit designs.

2. By contact with a deep, highly concentrated, dense bed or "blanket" of accumulated solids in a zone comprising the bottom cone and one or two feet of straight height above the bottom straight of the tank. With large S units, this deep sludge bed provides concentrations of 3000 to 8000 ppm of solid magnesium hydrate precipitates for 10 to 20 min reaction time and effective, low-cost silica removal is thus obtained with very small quantities of makeup MgO. Silica concentrations below 1 ppm are obtained in the effluent from large units employing minimum amounts of makeup MgO compounds with influent concentrations of 50 ppm silica. Fig. 7 shows a flow sheet and influent and effluent analysis of a typical Type-S hot-process installation, 100,000 lb per hr outlet capacity, employing a deep sludge bed for effective silica removal. Type S unit designs provide maximum "Density-Time" concentrations of MgO for optimum silica reduction.

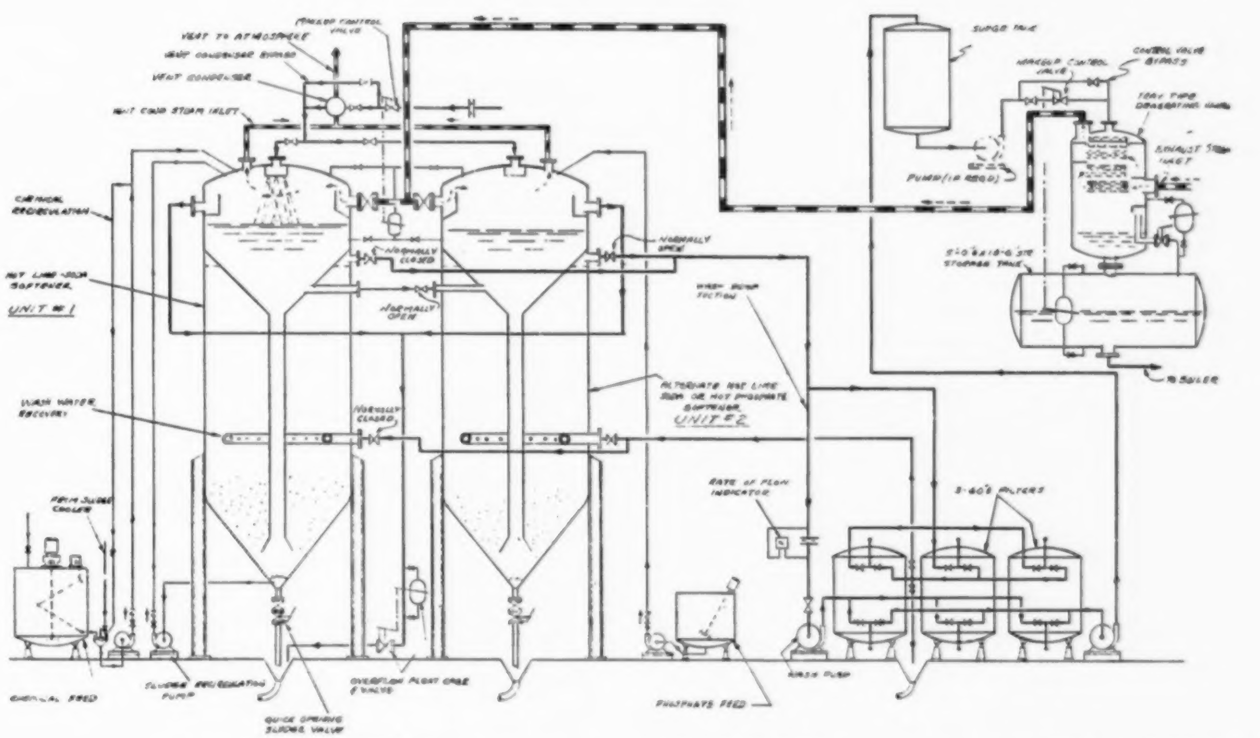
Laboratory research has indicated that magnesium hydrate precipitated *in situ* is more effective for silica removal than solid MgO added in the form of specially activated compounds or from dolomitic lime. However, the MgO available from dolomitic lime has been found to be less expensive and virtually as effective as activated compounds in silica reduction when employed in a deep dense bed of sludge, as with Type S units.

Research and analyses also indicate that silica removal by contact with solid magnesium hydrate at high temperatures involves, in part, complex basic magnesium silicate compound formation rather than pure adsorption (1, 2, 3). As is well known, absorption or adsorption phenomena are most effective at lower temperatures. With silica removal by contact with solid magnesium compounds, the reverse is true. The mechanism appears to be one involving hydration of MgO and absorption of silica followed by compound formation. We are forced to conclude from tests that compound formation at high temperature and high pH is a probable mechanism of reaction here even though a Freundlich isotherm-type relation could be established for reduction of silica at a given temperature level.



	Cations, ppm as $CaCO_3$				Anions, ppm as $CaCO_3$							Other constituents			
	Ca^{++}	Mg^{++}	Na^{+}	Total	HCO_3^{-}	$CO_3^{=}$	OH^{-}	$SO_4^{=}$	Cl^{-}	$PO_4^{\equiv}$	Total	Ppm as SiO_2	Ppm Turbidity	Ppm Color	pH
Raw Lake Water	85	35	75	195	130	0	0	50	15	0	195	3-4	10-40	10-20	7.0
Treated Water	0-1	0-1	131	133	0	45	15	50	15	8	133	1-2	...	...	10.4

Fig. 6—Flow sheet with influent and effluent analysis of typical 1,000,000 lb-per-hr hot-process installation employing sludge recirculation for silica reduction



	Cations, ppm as $CaCO_3$				Anions, ppm as $CaCO_3$							Other constituents			
	Ca^{++}	Mg^{++}	Na^{+}	Total	HCO_3^{-}	$CO_3^{=}$	OH^{-}	$SO_4^{=}$	Cl^{-}	$PO_4^{\equiv}$	Total	ppm as SiO_2	Ppm turbidity	Ppm color	pH
River Water	188	61	28	277	192	...	...	72	13	...	277	8.7	20–40	...	6.7
Treated Water	0-1	0-1	138	140	...	50	...	72	13	5	140	23	...	...	10.3

Fig. 7—Flow sheet with influent and effluent analysis for a typical installation of 100,000 lb-per-hr outlet capacity employing deep sludge bed for silica removal

Although clarity of effluent is mainly a function of low settling rate or maximum settling area in the separation zone, there is sufficient empirical evidence to indicate that the deep sludge bed in the S type unit does improve the clarity of effluent by improving the removal of fine particles and reducing effluent turbidity.

Factors Influencing Separation of Precipitated Solids from Treated Water

Frequently, it is not realized that the hot-process softener is also a hydraulic separator of solids from a liquid (treated feedwater). Once the solid precipitates are properly formed in the chemical reactions and efficient silica reduction by contact with MgO containing solids is obtained, the hot-process softener must be designed so that maximum separation of all the solids (both coarse and fine particles) from the treated liquid is accomplished.

Since hot-process softeners are units with up and down travel of water, chemical and sludge, the factors which influence the clarity of treated water obtained from the hot-process softener are:

1. Upward velocity of treated water in the region where separation of solids from the water occurs. This is also called the upward settling rate and is usually expressed in gpm per sq ft.
2. Height of liquid up to the collector and total retention time in the separation zone.
3. Viscosity of the treated water. This value is mainly a function of the water temperature.
4. Density of the treated water.
5. Density of solid particles.
6. Size of solid particles.

In a quiescent medium, the settling velocity of a solid particle in water may be calculated from Stoke's Law (3) as follows:

$$V = \frac{73.9D^2(S_1 - S_2)}{Z}$$

where

V = Velocity of fall in feet per second
D = Diameter in inches of particle
S_1 = Density of particle in pounds per cubic foot
S_2 = Density of fluid in pounds per cubic foot
Z = Viscosity in centipoises

However, in a hot-process softener of the present general design, solid particles must be settled out downwardly from the treated water which has an upward velocity and upward force component. In order to understand clearly the importance of designing such a softener for maximum settling zone area, greatest height and maximum water and reaction temperature, it is well to analyze the problem and establish the various factors which come into play when a solid particle of a given size and density is supported at a given plane by virtue of an upward force created by upward water velocity and displacement.

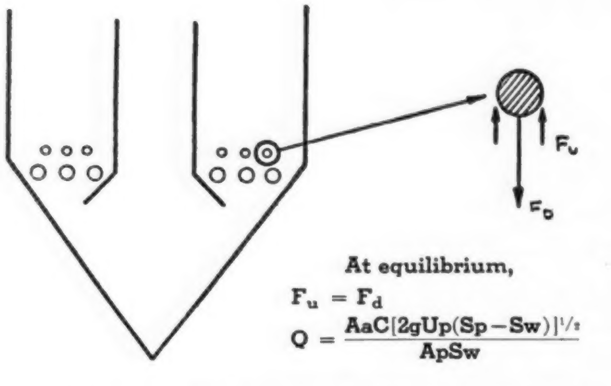


Fig. 8—Relation between particle size and settling area in hot-process tanks.

At equilibrium the solid particle is stationary at a given upward flow rate and therefore, the downward and upward forces acting upon it are equal; see Fig. 8. The downward force is equal to the weight of the particle less the weight of the water it displaces and can be expressed as follows:

$$F_d = U_p(S_p - S_w) \tag{1}$$

where

U_p = Volume of the particle
S_p = Density of the particle
S_w = Density of the water

The upward force is equal to the difference in fluid pressures between the upper and lower sides of the particle multiplied by the cross-sectional area on which the pressures are exerted. That is,

$$F_u = (P_d - P_u)A_p \tag{2}$$

where

P_d = Fluid pressure on lower side of particle (in weight units)
P_u = Fluid pressure on upper side of particle (in weight units)
A_p = Cross-sectional area of particle

At equilibrium when the solid particle is stationary, these two forces are equal.

$$F_d = F_u \tag{3}$$

$$U_p(S_p - S_w) = (P_d - P_u)A_p \tag{4}$$

Converting to difference in head of water flowing, we obtain:

$$h = \frac{P_d - P_u}{S_w} = U_p\frac{(S_p - S_w)}{A_p\, S_w} \tag{5}$$

Equation (5) represents the net pressure drop across the particle and, neglecting friction, is seen to depend only on the particle dimensions and the densities of particle and fluid.

For flow of water or a fluid past the aperture surrounding a solid particle in a medium of solid particles suspended at a given plane in water it can be said that

$$V = C(2gh)^{1/2} \tag{6}$$

where

V = Velocity of water, feet per second
g = Acceleration due to gravity
h = Head of water in feet
C = Coefficient of flow friction depending mainly upon viscosity of the water and smoothness and area of the surface of the solid particles. The greater the viscosity, the lower is C

$$V = \frac{Q}{A_a} \tag{7}$$

where also

Q = Volumetric rate of flow in cu ft/sec
A_a = Average area around the edge of the particle through which the water flows upwardly

And by combining equations (5), (6) and (7), we obtain:

$$\frac{Q}{A_a} = V = C(2gh)^{1/2} = C\,\frac{[2gU_p(S_p - S_w)]^{1/2}}{A_pS_w} \tag{8}$$

$$Q = A_aC\,\frac{[2gU_p(S_p - S_w)]^{1/2}}{A_pS_w} \tag{9}$$

Equation (9) is the basic equation defining relationship between flow that will suspend a solid particle at a given plane and properties of the particle and the water flowing past the particle. This equation clearly shows the following:

(*a*) The bigger the aperture or area of water flow surrounding the solid particle, the greater the flow which can be pushed past the particle and suspend it motionless without carrying it up and over as turbidity into the collector. This provides a theoretical basis for the already applied principle of maintaining the greatest area in the settling (or separation) zone, so that all the solid particles are separated from the treated water.

(*b*) Since a hot-process softener and all other types of upward flow units have relatively large concentrations of solids of different sizes in a given space, the presence of a great height of column through which the fluid must flow results in each particle finding its own plane of separation where the aperture area is large enough to just suspend the particle by difference in water pressure loss. In effect, then, a cylindrical column in which these solid particles are suspended is one in which there is an increase in average liquid flow area between the solid particles at planes in the lower regions where the heavier, coarser particles are found and the lighter particles in planes at a higher level. This formula provides the theoretical confirmation of the practical application in hot-process design of a high column of clear water above the optimum solids-from-liquid separation point and up to the effluent collector.

(*c*) C, the coefficient of flow friction, is a function of viscosity of the water, smoothness, and area of the surface of the solid particle.

$$C = \frac{K}{Z(\pi D_p^2)}$$

where

D_p = Average diameter of particle assuming spherical shape
Z = Viscosity of the water
K = Smoothness coefficient of particle

This is the theoretical basis for the practical engineering principle that the lower the water viscosity (i.e., the higher the water temperature), the greater is C and the greater the flow that can be pushed past the particle to maintain it suspended at a given plane. The peripheral area over which water flows and the smoothness coefficient of the particle surface also come into consideration of the picture.

(*d*) The greater the difference in density between particle and water, (i.e., $S_p - S_w$), the greater is the upward water flow which can be permitted to suspend the particle at a plane. This is a square root function.

(*e*) The greater the volume of the solid particle, for a given particle density, the greater the downward force component (square root function). This is because the volume of a particle varies as the cube of the diameter, whereas surface area, which is related to upward frictional force, increases as the diameter squared. This is the theoretical basis for design of hot-process equipment where every attempt is made to increase solid particle size and thus improve settling.

As indicated previously, in practice, a hot-process softener may be one of three basic commercially tested designs as shown in Fig. 3. These three types are as follows:

Type U—Older, conventional-type unit designs with conical uptake collector. Contact with solids provided by sludge recirculation only.

Type F—Small diameter, downcomer-type (less than 5 per cent of total tank area) unit with bottom of downcomer extending only to bottom straight of shell. Contact with solids provided by sludge recirculation mainly.

Type S—Small diameter, downcomer-type (less than 5 per cent of total tank area) unit with bottom of downcomer extending below bottom shell straight and more than 40 per cent of vertical height into the bottom cone. Contact with solids is provided by upward flow through a deep, highly concentrated bed of sludge plus sludge recirculation, in some cases.

Settling Area Important

The foregoing analyses show that for a given tank diameter and straight height, it is important to obtain maximum settling area in order to settle out fine as well as coarse solids. The F and S-unit designs, with downcomers occupying less than 5 per cent of the total unit area, provide maximum area (more than 95 per cent of the total tank area) for settling out solid particles of precipitates.

Furthermore, it is important to maintain as great a height as possible in the settling zone in order for the finer solid particles to find a separation plane of their own far below the effluent collector system and thereby never carry over in the form of turbidity. The F and S unit designs with 50 to 75 per cent of the total height and retention time in the tank available between the solid separation zone near the bottom straight of the tank and the collector system, provide optimum design for this purpose.

The advantages of "F" and "S" units over the older "U" type units have been clearly proved in practice by the operation of many plants (Ref. 4, 5, 6, 11). The final proof of the effectiveness of hot process softener design is the clarity of the effluent on an hour-to-hour basis, 24 hours per day, regardless of fluctuations in load (ref. 7). A properly designed and well-operated plant requires filter backwashings not more than once every 24 or 36 hours at a 3 or 4 psi loss.

The essential weakness of the older U-Type units is the fact that there is a reversal of the logical design for optimum mixing and hydraulic separation. In other words, while mixing of heated water with chemicals and sludge (if used) is carried out in the full unit area for a period of more than 50 to 75 per cent of the total retention time, settling of solids is carried out in a separation zone where the settling area is reduced to less than 50 per cent of the total unit area; and this is for only 15 to 30 per cent of the total retention time in a relatively shallow height of fluid in the conical uptake. Still another advantage of the F and S designs is the availability of large volumes of clear, treated water after solids separation, for backwashing the filters.

On the other hand, an advantage of the U type is that it can provide up to 80 per cent of the available retention time in the softener tank as storage for a boiler feed pump in case of rapid surge demand; whereas with F and S unit designs, only 25 to 50 per cent of the softener tank holdup is normally available because of the elevated collector system. This available storage can be increased by increasing the holdup above the collector system or by inserting a manually operated bypass valve at a point below the collector system so that this valve can be opened in case more boiler feedwater is required suddenly.

In practice each of these units may have specific advantages for individual applications and must be considered in relation to definite operating conditions at each boiler plant.

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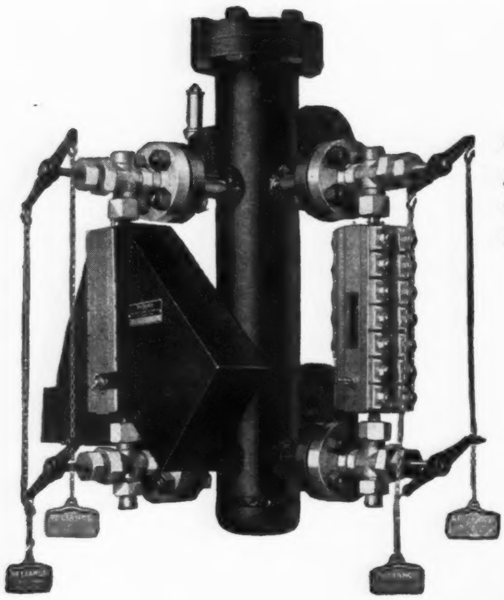

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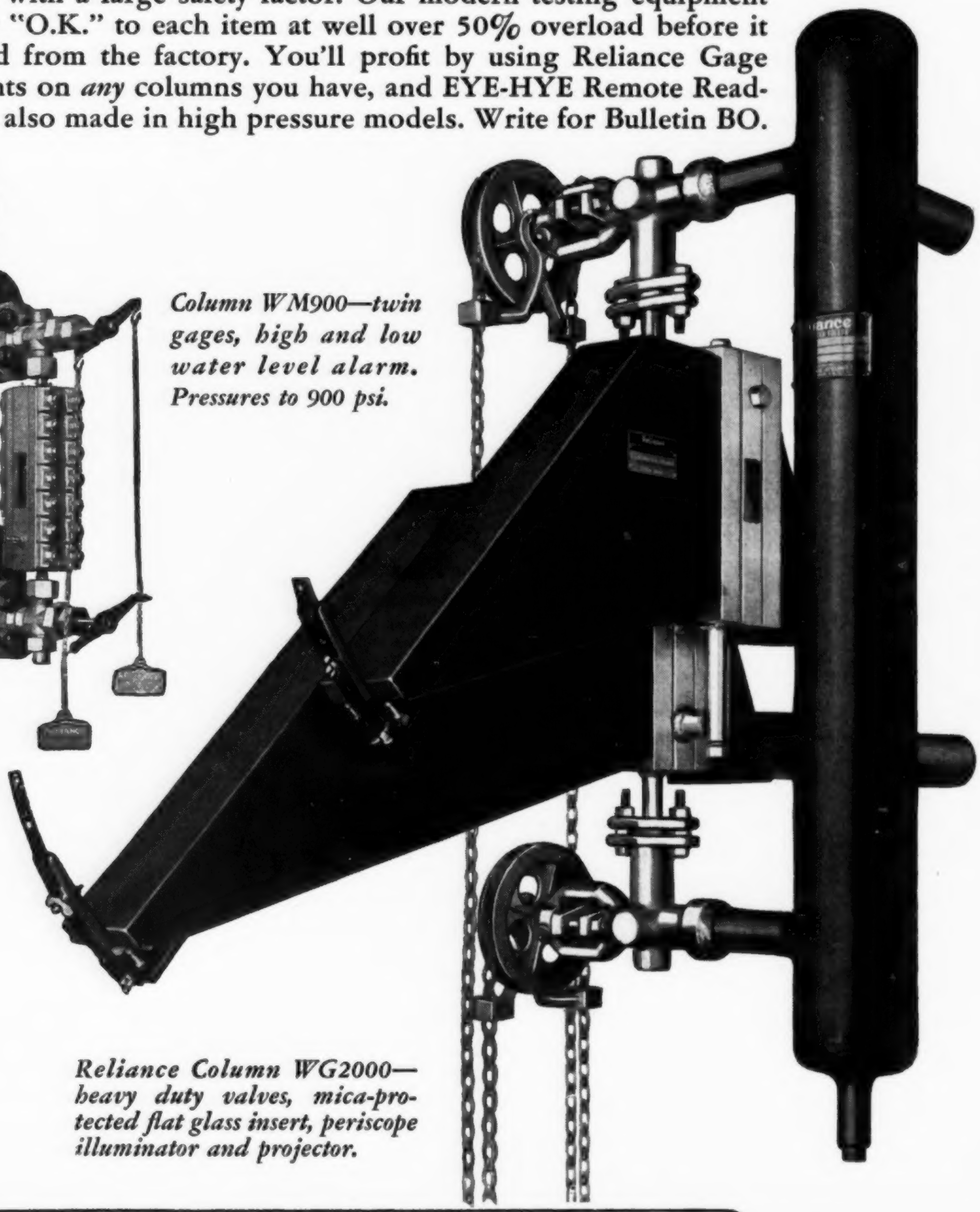

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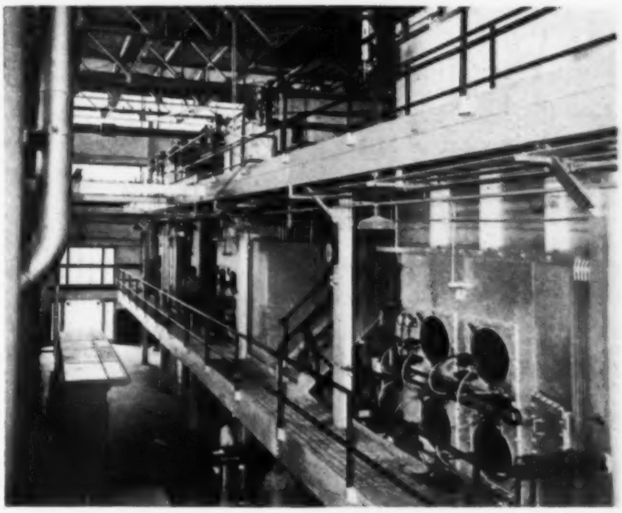

THE ACCOMPANYING photographs show the new Cabrera Power Station of La Electricidad de Maracay, a public utility supplying electricity to the city of Maracay, Venezuela, which operates under the presidency of L. E. Galavis who, incidentally, received his engineering education in the United States at Rensselaer Polytechnic Institute. It is owned and operated by C. A. La Electricidad de Maracay, a department of the federal government, which also has three other plants, a diesel station some 25 years old and two small hydro plants. The load, which comprises city lighting, residential and industrial uses, and agricultural pumping, has shown a 30 per cent increase during the past six months and thus made it necessary already to consider plans for extending the Cabrera Station by 20,000 kw.

At present the plant contains three 80,000-lb per hr C-E two-drum steam generating units, oil-fired with Peabody burners and operating at 415 psi, 725 F with 375-F feedwater. These moderate steam conditions were dictated by the size of the units. Elesco superheaters, tubular air heaters and Bailey combustion control are incorporated in the units. Steam is supplied to two 7500-kw standard G-E turbine-generators. Condensing water is taken from Lake Valencia and boiler makeup is from artesian wells.

Despite the abundance of oil in Venezuela, it is not cheap at the Cabrera Plant inasmuch as it has to be trucked a considerable distance and trucking charges are high. However, it is anticipated that natural gas may be available to the locality before long.

Higher Court Decisions Affecting Steam Plants

by LEO T. PARKER

Attorney at Law, Cincinnati, Ohio

A review of some miscellaneous court decisions involving such matters as contracts in violation of state laws, patents, implied guarantees, insurance and enjoinment of smoke.

RECENTLY, a reader wrote: "If an employee contracts a disease due to the employer's failure to provide adequate safety measures, can the employee recover compensation under federal and state law that authorizes payment of compensation to employees 'injured' while attending to their regular work? Can an employee receive compensation under similar conditions under the Federal Boiler Inspection or Safety Appliance Acts?" These questions of law were only recently decided by the United States Supreme Court which held in the affirmative on the grounds that an occupational disease is legally an injury.

Also, Supreme Court held that under the Federal Boiler Inspection or Safety Appliance Acts an employer is liable for payment of compensation to an employee who contracts a disease while doing interstate work, as a result of his employer's negligence to provide safety devices, apparatus, etc., to safeguard against contraction of diseases.

For example, in *Urie v. Thompson (69 S. Ct. 1018)*, it was shown that one Urie had been employed as a fireman for approximately thirty years, and had been forced to cease work because of a pulmonary disease diagnosed as silicosis. This permanently disabling affliction, it was claimed, had been brought on by continuous inhalation of dust. The question presented the court was: Does the coverage of the Federal Employers' Liability Act and the Boiler Inspection Act include injuries in the nature of occupational disease, such as silicosis, or is it confined exclusively to injuries inflicted by accident?

The lower court decided in the negative, but the Supreme Court reversed the verdict on the grounds that the evidence showed Urie's disease to have been caused by the employer's failure to provide safety measures and apparatus that would remove injurious dust from the air. The Court said:

"We recognize, with respondent, that the Federal Employers' Liability Act is founded on common-law concepts of negligence and injury.... In our view, when the employer's negligence impairs or destroys an employee's health by requiring him to work under conditions likely to bring about such harmful consequences, the injury to the employee is just as great as when it comes with the suddenness of lightning.... Thus the Boiler Inspection Act vests in the Interstate Commerce Commission rule-making power adequate to protect employees against disease as well as against accident; and the power to make rules for employee health has been exercised.... We hold that petitioner's injury is one compensable under the Boiler Inspection Act."

In contrast, however, the same court held in another case (*Hurle, 104 N. E. 336, L.R.A. 1916A, 279, Ann. Cas. 1915C, 919*) that blindness caused by noxious industrial vapors was a "personal injury."

License vs. Sale Contract

Considerable discussion has arisen from time to time over the question: If a company violates a state's license law and fails to obtain a license to install steam equipment, can it collect payment from a purchaser of the equipment? The answer is yes, providing the company sues *not* for services rendered but for the contract price of the equipment.

For instance, in *Hagan v. Allen Company (210 Pac. (2d) 65)* testimony showed that the El Rey Cheese Company purchased a steam boiler from the Allen Company which agreed to construct and deliver it to the cheese company's place of business. At the same time the seller advised the purchaser that a steam separator would be included to insure delivery of dry steam under normal working conditions; also that although an expert would be required to set the controls initially, anyone thereafter could operate it. The Allen Company built, delivered and installed the unit, and subsequent to which the cheese company's employees did not operate it properly and serious damage resulted. The purchaser refused to pay the contract price and the seller filed suit to recover. During the trial counsel for the cheese company submitted proof that the seller had no license in the state to install steam equipment and therefore contended that, since it had violated the state law it could not recover the contract price. The higher court refused to agree with this contention and held that the cheese company must pay the full contract price, saying:

"Appellant (cheese company) asserts that because respondent (seller) was not licensed to install steam equip-

ment the latter was precluded from recovering.... Thereby appellant (cheese company) overlooks the fact that respondent's (seller's) claim was not based upon services rendered in installing the generator, but upon the contract price for the equipment delivered."

Law of Patents

Not long ago one White invented and obtained a patent on an improvement having to do with steam engines. He asked this question: "Does my patent give me protection against infringement by manufacturers on what is shown in the drawings? Most of my claims are very lengthy. Does this mean that I have a good and strong patent?"

First, it is important to know that an inventor never is protected against infringement by what is shown in his patent drawings unless *also* he is awarded "claims" which broadly describe the invention or its parts shown in the drawings. It is well established that each claim of a patent covers a *complete* invention in itself and an independent invention.

The correct method for writing strong and basic claims is to have each claim speify some particular step or advantage, and when a claim is poorly drawn and very lengthly it is usually weak. For, reference, see *178 F. 552; 181 F. 96; 222 F. 261.* Other courts have held that *basic* patents have *short* claims.

The courts have repeatedly held that a pioneer or basic patent is liberally and broadly construed in favor of the inventor, and that all subsequent machines or devices which employ substantially the same mode of operation or parts are infringements; see *105 F. 624; 115 F. 498; 127 F. 341;* and *137 F. 68.* Nevertheless, no inventor is protected by a patent unless the basis elements desired to be protected are shown in both the drawings and the claims. Of course, also, the same must be described in the specifications.

It is well known among patent law experts that numerous companies expend large sums annually to obtain patents which are valueless and void. No patent is valid which protects a device so simple that any ordinary mechanic may perfect it. In other words, an improvement to an apparatus to be patentable must be the result of invention, and not the mere exercise of ordinary skill.

For example, in *Illinois Welding Accessories Company v. Johnson Equipment Company* (*161 Fed.* (*2d*) *624*) the testimony showed that an inventor obtained a patent containing fine drawings of his invention, but having lengthy claims.

In holding the patent void, the higher court said:

"It will be seen that the claims of invention are very narrow.... Mechanical skill is one thing: Invention is a different thing.... An instrument or manufacture which is the result of mechanical skill merely is not patentable.... We conclude that there is nothing in any of the claims patentable over the prior art and that the claims merely carry forward old ideas changed in proportion or degree and embracing additions and modifications that would suggest themselves to any skilled mechanic. This does not amount to invention."

Implied Guarantees

Modern higher courts consistently hold that sellers may be liable on implied guarantees that salable merchandise and equipment is reasonably worth the purchase price. According to a recent decision there is no implied warranty as to the quality or fitness for any particular purpose of merchandise or equipment under a contract of sale, except, (1) where the buyer makes known to the seller the particular purpose for which the merchandise or equipment is required, and that the buyer relied on the seller's skill, or judgment; or (2) where the merchandise or equipment is bought by description. Otherwise there is no implied guarantee.

For example, in *Whitin Machine Works v. United States* (*175 Fed.* (*2d*) *504*) the testimony showed facts, as follows: The company sold certain equipment including a single-cylinder reciprocating steam engine. The sale contract contained a clause to the effect that, "Materials shall be in accordance with accepted commercial practice.... Governor shall be capable of controlling the revolution of the engine within 10 per cent of the normal revolutions when the unit is operating at full power with a steam pressure of 220 psi and the circuit-breaker is tripped."

The flywheel was provided with a metal guard for protection of the engine room personnel, and a governor controlled the speed. The engine was designed to run at 400 rpm under a load, and 410 rpm with no load. With the load suddenly lost the engine would immediately speed up to 430 or 440 rpm but the governor was expected to bring the speed down to 410, in one or two seconds.

One day the governor failed to function and the engine speeded up excessively with the result that the flywheel burst and flying fragments injured two employees. The purchaser paid heavy damages to the injured employees and then sued the manufacturer to recover, contending that Whitin Machine Works was liable because it improperly warranted the flywheel to be without defects and of sufficient strength to withstand the centrifugal force at a runaway speed far in excess of the maximum of 440 rpm.

The manufacturer proved that the flywheel was made of cast iron, in accordance with accepted commercial practice for flywheels on engines of this type, with a certain amount of steel added to the mixture in order to increase the tensile strength. Also, it had a factor of safety of 10 which is generally accepted as good practice. The only latent defect in the flywheel suggested by the evidence was a certain amount of porosity.

In this case the higher court refused to hold the Whitin Machine Works liable, and said:

"It is undisputed that there is a tendency to porosity in any casting, for the reason that as the molten metal cools and solidifies it contracts.... Whitin Machine Works made daily tests of samples taken at various times from the melts of metals that went into the flywheel castings to determine the chemical ingredients and breaking strength of the material."

Consideration Required

Modern higher courts consistently hold that a contract without legal "consideration" is void. This means that a promise made or an obligation assumed *after* an installation contract is signed is void.

For illustration, in *Power Service Corporation v. Joslin Plumbing Company* (*175 Fed.* (*2d*) *698*) the testimony

showed that after a seller of steam equipment made a bid, which was accepted, a notation signed by the seller was attached to the contract which imposed liability upon the seller for delay in furnishing materials and completing the work within a specific period.

The court held the seller not obligated by the signed notation, saying:

"The terms of the contract became fixed and the parties were bound when the bid was accepted...any attempt to alter that specification by the addition was ineffective for want of any consideration."

Ambiguous Insurance Policy

Many erroneously believe that an ambiguous insurance policy is void, but this is *not* so. According to a recent higher court one may expect that the court will decide in his favor in a suit involving payment of insurance if a clause in the policy is ambiguous. This is so because where an insurance policy is ambiguous it will be construed strictly against the insurance company.

For illustration, in *Great American Company of New York v. O. K. Packing Company (211 Pac. (2d) 1014)* it was shown that the packing company held an insurance policy containing a clause that it did not cover losses caused by explosions originating within steam boilers, steam pipes, etc.

One day an explosion originated in a steam-heated tank used for rendering lard and tallow from waste and scrap meats. A steam pipe connected the tank with the boiler. The explosion hurled the tank and its contents through the roof and a distance of some 300 yards, shearing off the rivets that held the valve at the base of the tank.

In subsequent litigation the higher court held that the insurance policy covered the loss. The court said:

"Where the language of an insurance policy is ambiguous or susceptible of two different constructions, it will be strictly construed *against* the insurer, and that construction adopted which is most favorable to insured."

Plant Owner Liable

Recently a higher court rendered a decision to the effect that a plant owner is liable for damages caused by a steam plant although the testimony showed that the thing which caused the damage was installed and maintained by an independent contractor.

For example, in *Levine v. Bochiaro (59 Atl. (2d) 224)*, testimony showed that one Pecorella owned a factory building in which were installed two boilers connected to a common stack. One of these boilers, which was oil fired, exploded.

Several customers had sent materials to the factory to be processed and these were destroyed. Their owners sued the plant owner for their value. The latter attempted to avoid liability by proving that he had employed a company which acted as an independent contractor to maintain and repair the boiler which exploded. The higher court refused to hold in favor of the plant owner, and said:

"If it may be assumed that the plaintiffs' loss resulted solely from the failure of Milos (contractor) to make proper repairs to the oil burner, defendant (Pecorella) nevertheless is liable."

Court Enjoins Smoke

Considerable discussion has arisen from time to time over the question as to under what circumstances may owners of dwellings enjoin a nearby steam plant from emitting smoke. The answer is: A property owner can obtain an injunction against operation of a legal nuisance which started operating *after* the dwellings were occupied.

For example, in *Kepler v. Industrial Disposal Company, 85 N. E. ((2d) 308)* it was shown that owners of nearby dwellings filed suit and asked the court to grant an injunction against a plant emitting smoke and odors, which were noxious and offensive.

The higher court granted the injunction in view of the fact that the dwellings were constructed and occupied *before* the company started its operations.

Law of Insurance

Many owners of steam plants do not realize the importance of knowing the law of insurance. This is so because many plant owners pay insurance premiums for years and then when a loss occurs, the insurance company does not, by law, have to pay off.

According to late and leading higher court cases an insurance policy does not give the intended protection if the insured is guilty of any of the following acts:

He made a false statement or representation at the time of filing application for insurance. He violated some valid law, as a direct or indirect result of which the loss occurred. For example, violation on the part of the insured of a state law or city ordinance as to elimination of fire hazards, or other such law, affords the insurance company an opportunity to refuse payment. Also, if the insured violates any clause in the insurance policy the insurance company may refuse to pay the loss. This is so because an insurance policy is a legal contract, and the company is no more liable on the contract than any other person or company if the insured breaches his agreement.

Another very important point relative to insurance is that if you instruct the ordinary insurance agent as to the type of protection you desire, the insurance company is not responsible if the agent fails to supply a policy which contains this protection; see *N. Y. Insurance, 183 U. S. 25; American, 170 U. S. 133; Travelers, 91 Fed. (2d) 377; and Sentinal Insurance, 77 Fed. (2d) 347.*

On the other hand, if an insured, who is doubtful as to the protection his policy affords, instead of relying on the promises made by an ordinary or special insurance agent, gets or receives assurance or statements from a general agent of the company, the insurance company is fully liable and responsible for assurances or promises made by the general agent; see *Metropolitan Insurance, 277 U. S. 311.* Therefore, any plant owner who is doubtful as to the protection afforded by a policy should contact the general agent of the insurance company in his locality, and receive by letter explanations and statements which will verify the special agent's promises as to the coverage of the policy.

Still another important point of law relative to insurance is this: Never move insured property without receiving from the insurance company a "rider" to be attached to the policy. Also, if insured property is mortgaged the insured should be certain to notify the general agent of the insurance company and receive a rider to this effect.

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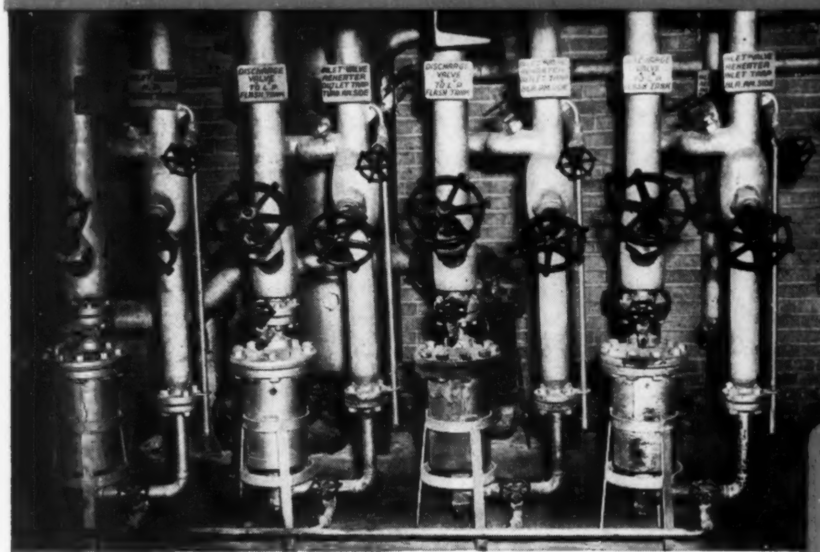
steam traps



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VALVE AND SEAT:
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BUCKET and VALVE LEVER ASSEMBLY:
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BOLT and NUT SET:*
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Nuts, hex, semi-finish, S.A.E. 1030

GASKET:*
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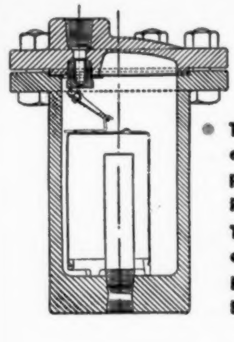

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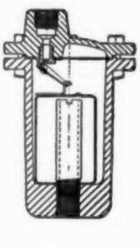

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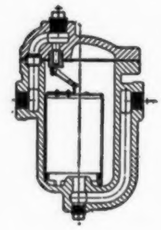
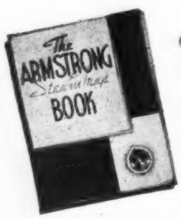


- Side inlet cast steel trap for pressures to 600 psig, screwed or flanged connections.



- FOR COMPLETE DATA ask for the 36-PAGE ARMSTRONG STEAM TRAP BOOK or see our catalog in Sweet's.

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ARMSTRONG STEAM TRAPS

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Steam Turbines and Their Cycles

By J. Kenneth Salisbury

This subject has been dealt with in many texts, usually as part of textbooks written by professors with a view to acquainting undergraduate students with the fundamentals of power generation; but such information is obviously quite general. Of the very few authoritative treatises on the subject of steam turbines, such as the classic work of Stodola, most are now more or less out of date. In view of this the present contribution by Mr. Salisbury meets a widely felt need by providing an up-to-date, authoritative and practical volume that should be most useful to the practicing engineer. As to the author's qualifications, it may be mentioned that he has long been associated with the Steam Turbine Department of General Electric Company and contributed outstanding papers on this subject to the American Society of Mechanical Engineers, of which he was the 1942 Melville Medallist.

A brief review of the contents reveals, among others, chapters on thermodynamics, power plant cycles, flow of liquids, turbine design and characteristics, cycle analysis, with particular reference to the regenerative cycle and heat balance, heater arrangements, design details, estimating heat rates, and various other factors affecting performance. The effect of many variables on plant performance is discussed at length. An appendix contains data often required by the application engineer in calculating heat balance.

Bound in cloth, with 645 pages, 6 × 9 in., the book is priced at $9.00

Properties of Metals at Elevated Temperatures

By George V. Smith

Future developments in steam and nuclear power plants are to a large extent dependent upon advances in high-temperature metallurgy. This book, written by an engineer with broad research experience in the laboratory of the United States Steel Corporation, fulfills a need for systematized knowledge of developments which have taken place or may be expected in making available suitable high-temperature materials.

In addition to the engineering data that have been published on creep and the strength of materials at elevated temperatures, there is need for knowledge of the fundamental mechanisms of plastic deformation under stress at elevated temperature and the effect of grain size, recrystallization, distribution of the phases, and phase changes. Much of the attention of Dr. Smith's book is devoted to information of the latter sort, a task which is made more authentic by the inclusion of a bibliography of nearly 500 references.

Fundamentals are stressed in the first few chapters, which deal with the nature of plastic deformation and fracture of metals from a metallurgical point of view. By explaining the phenomena at both ordinary and elevated temperatures, the author provides a clear picture that aids in the comprehension of the complex factors involved. In later chapters test apparatus and test procedures used for determining metal properties at elevated temperatures are described. Then there are chapters devoted to the effects of chemical composition on creep, of melting and deoxidation practices, of heat treatment and grain size, and of varying temperature and load. The book concludes with an extended discussion of changes during service and of practical problems in designing for elevated-temperature service.

Dr. Smith's work is recommended to those interested in understanding the metallurgical problems of high-temperature applications. There are 401 pages and the book sells for $7.

Elements of Internal Combustion Turbine Theory

By H. T. Adams

This short book presents the underlying theory and some of the empirical considerations involved in gas-turbine design. It assumes that the reader has a background in advanced engineering mathematics and aerodynamics. A number of examples that have been worked out completely or partially aid in the comprehension of the text; they also show the application of many of the complex physical theories to gas-turbine design.

There are chapters devoted to Thermodynamic Considerations, The Centrifugal Compressor, The Axial Flow Compressor, The Turbine, Stress Calculations, Vibrations, Critical Speeds and End Loads, Overall Performance Correction and Estimation, and Heat Exchange and Intercooling.

The author formerly was Director of Studies to Power Jets Ltd. and is now serving as Senior Lecturer in Mechanical Engineering at Canterbury University College, New Zealand. The book contains 178 pages and sells for $3.75.

Hydroelectric Handbook

Edited by W. P. Creager and J. D. Justin

The Second Edition of this authoritative handbook includes data on the most recent advances in the design and operation of hydroelectric power developments. Assisted by 18 contributors, the editors have attempted to present an accurate picture of the problems involved in hydro developments and to provide sufficient data for preliminary designs, cost estimates and reports. The book has four major divisions: Preliminary Studies and Economics, Dams—Design and Construction, Conduits and Powerhouses, and Equipment and Operation.

Engineers in the steam power field will find Chapters 12 to 15, entitled, respectively, Cost of Steam Power, Cost of Hydro Power, Market Requirements and Load Studies, and Capacity of the Development and Economic Advisability of Hydro, of considerable interest. It is to be regretted, however, that the bibliographies accompanying these chapters include no listings later than 1939.

Both authors have had extensive experience as consultants on hydroelectric projects in this country and abroad. Their efforts have resulted in an exceptionally well-detailed and comprehensive handbook of hydroelectric practice. There are 1131 pages, and the book sells for $12.50.

Betz Handbook of Industrial Water Conditioning, Third Edition

It is unnecessary to review in detail this well-known and highly regarded handbook which first made its appearance in 1942. Three years later it was revised and amplified, and the present edition represents a complete revision embodying the latest developments in industrial water conditioning of which feedwater and boiler-water treatment play a major rôle.

Part I devotes 114 pages to the subject of water treatment and Part 2, 50 pages to water analysis. It is one of the most complete and practical works on the subject and is based on the experience and technical knowledge of the W. H. & L. D. Betz organization, chemical engineers and water consultants of Gillingham & Worth Sts., Philadelphia 24, Pa. Printed on coated stock, $8^1/_4 \times 10^3/_4$ in., with flexible cover, it carries the nominal price of $2.

Sales Engineering, Second Edition

By Bernard Lester

Perhaps one of the least understood phases of engineering is that dealing with the sale of machinery, equipment and technical products. With the ever increasing use of "high-pressure" selling for consumer goods, it is natural to assume that industrial equipment is sold in a similar manner. However, Mr. Lester carefully differentiates methods applicable to each and points out that in sales engineering a successful sale is both a profit-

able sale to the supplier and a profitable purchase to the buyer.

There are five parts to the book: The Field of Sales Engineering, Buying and Selling, The Sales Engineer in Action, Selling to Those Who Buy for Resale and The Training and Development of the Sales Engineer.

The effectiveness of the text is enhanced by the skillful use of interesting case studies of actual industrial selling problems. Anyone who has been concerned with either buying or selling a major piece of power-plant equipment will recognize the practical usefulness and wisdom of the suggestions made in the case studies.

Mr. Lester has had a long background of sales experience with the Westinghouse Electric Corporation and is now a partner in Lester, Hankins & Silver, management consultants. His book should be of interest not only to those actively interested in sales work but also to engineers who can profit by an understanding of the function of incoming business in supporting other forms of engineering activity. There are 226 pages and the book sells for $3.

Use of High Temperatures in Gas Turbines

A paper by T. W. F. Brown of the Parsons and Marine Engineering Turbine Research and Development Association, delivered before The Institution of Mechanical Engineers (Great Britain), makes a comparison between gas-turbine cycles with inlet temperatures of 1250 and 2200 F. At the latter temperature cooling of highly stressed parts will have to be provided as there is no indication that new materials will become available in the near future to operate under high load at such temperatures for long periods.

There are two types of cooling that have been suggested: (1) water cooling and (2) air cooling, which may be either boundary layer cooling with air admitted through thin slots, or sweat cooling which involves porous materials through which air percolates.

At temperatures on the order of 2200 F the author considered the use of the closed or semi-closed gas-turbine cycle impracticable and therefore directed his discussion toward open-cycle gas turbines. The principal parts affected include combustion-chamber design, turbine design and heat-exchangers, together with connecting piping conveying the hot gases between these units.

In the high-temperature gas turbine the excess air for full power would be around 65 per cent, compared to about 200 per cent now used for inlet temperatures around 800 F. Instead of an air-cooled metal wall around the flame zone in the combustion chamber, refractory or porous linings would be required. Duct work between the combustion chamber and the turbine would have to be kept at a minimum with temperatures on the order of 2200 F.

The only materials for turbine parts which are likely to be capable of operating at load without cooling at the tempera-

tures under consideration are ceramics, part ceramics, ceramels (a combination of ceramics and metals that are pressed and sintered or hot pressed), or ceramic-coated metals. Since both the losses and complications associated with blade cooling would be reduced, such ceramic materials would naturally lend themselves to use in blading.

For long-life gas turbines it is felt that ceramic materials should be developed for use as stator blading and that normal heat-resisting metal alloys should be continued for rotors and rotor blading. With the latter, water cooling is a possibility, provided that distilled water is employed to prevent deposits on the blading and rotor. Using a hollow rotor with radial holes in the blading communicating with the interior of the rotor, the water within the rotor circulates during rotation by a process of natural convection and so removes heat from the blades. This process, first suggested by Schmidt of Volkenröde, is aided by the strong centrifugal field which assists the convection. The arrangement is such that the pressure within the blading is approximately critical, a point where small changes in temperature cause large changes in density, thereby further increasing the natural convection. The heat abstracted from the gas by the blading generates steam in the rotor; a suitable pressure can be chosen and the steam expanded in a separate steam turbine, thus increasing the useful work done in the cycle.

Heat losses from cooling affect gas-turbine cycle efficiency in two ways: (1) by reduction of the turbine reheat factor and the overall turbine efficiency through a progressive decrease of gas temperature through the turbine, and (2) by reducing the turbine exhaust temperature.

The author reached the following conclusions: With cooling there is no inherent reason to prevent the use of high temperatures in gas turbines, and the resulting thermal efficiencies are such as to make the effort worth while. While water cooling results in the highest efficiency, sweat cooling has much to recommend itself for simplicity and in sets of smaller outputs. Water-cooled blades can have a surface temperature of 1200 F without the cooling having a serious effect upon efficiency.

June Energy Use Sets Record

According to the Federal Power Commission, production of energy by electrical utilities during June 1950 totaled over 26,685,000,000 kwhr which represents the highest June output of record, exceeding that of June 1949 by 13 per cent. Of this, water power accounted for approximately 30 per cent. Production for the 12 months ending June 30, 1950, exceeded 304 billion kilowatt-hours, which was 5.4 per cent over that of the preceding 12 months.

Installed capacity is given as 65,596,444 kw, over 700,000 kw having been added during the month and the net capacity increase for the 12-month period was 2,496,110 kw.

A.S.M.E. Fall Meeting

Worcester, Massachusetts, will be the scene of the A.S.M.E. Fall Meeting, scheduled for September 19–21 at the Hotel Sheraton. A feature of the meeting, in addition to the usual well-balanced technical program, will be the delivery of the Rice Lecture by Luigi Broglio, formerly of the Graduate College of Rome, Italy, on the subject, "The Method of Equivalence Applied to Engineering and to Mathematical Physics." A ladies' program is also planned and there will be inspection trips to the Worcester Pressed Steel Co., Norton Co., Heald Machine Co., the Fitchburg plant of General Electric Co., Crompton Knowles Loom Works, Bay State Abrasive Products Co., Telechron Co., Wyman-Gordon Co., Reed Prentice Corp., the Framingham plant of General Motors Corp., and Heywood-Wakefield Co. The following represents part of the technical and general program of interest to power men:

Tuesday, Sept. 19, 9:30 a.m.

"Ultrasonic Flaw Detection in Pipes by Means of Shear Waves," by C. D. Moriarty, General Electric Co.

"Bolted Joints for Piping Materials Having Widely Different Coefficients of Expansion," by E. G. Schmidt, E. P. DeCraene, I. H. Carlson and W. S. Black of the Crane Co.

"Management and Its Critical Opportunity," by Arthur B. Green, Consulting Engineer, Needham, Mass.

"The Engineer's Stake in Public Relations," by John D. Waugh, Pendray & Leibert.

Tuesday, Sept. 19, 2:30 p.m.

"Trend of Power Plant Practice in Germany," by Ludwig Musil, Graz, Austria.

"Trends in Modern Boiler Control," by John F. Luhrs, Bailey Meter Co.

Tuesday, Sept. 19, 8:00 p.m.

Junior Conference on the subject, "How Is Your Professional Development?" W. T. Alexander, Northeastern University, presiding.

Wednesday, Sept. 20, 9:30 a.m.

"Combined Steam and Gas Turbine Processes," by W. M. Rohsenow, Massachusetts Institute of Technology, and G. H. Bradley, Jr., American Viscose Corp.

"Convenient Gas Properties and Charts for Gas Turbine Calculations," by C. J. Walker, General Electric Co.

"Problems of Conversion from Coal Firing to Oil Firing," by D. H. Little, Boston Edison Co.

"The Use of Tungsten Carbide in Coal Pulverizers," by Wayne C. Rogers, Riley Stoker Corp.

"Standardized Boiler Units," by Carl E. Miller, Combustion Engineering-Superheater, Inc.

Wednesday, Sept. 20, 2:30 p.m.

"Steam Lift in Hot Process Water Softeners," by A. A. Kalinske, Infilco, Inc.

"Investigation of Steam Separation in Boiler Drums Through Studies on a Model," by E. A. Farber.

New Catalogs and Bulletins

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Air Traps

Armstrong Machine Works has issued a 4-page bulletin describing their line of air traps for automatic drainage of water from compressed air intercoolers, after-coolers, receivers, separators and drip points. Illustrations of air-trap models, their applications and how they work are included along with physical data and price lists.

Piping Products

A catalog recently published by Midwest Piping & Supply Co., Inc., contains a 65-page technical reference section on welded piping systems as well as extensive data on the Company's line of welding fittings. In addition to charts, tables, graphs, welding data, design formulas and metallurgical information, there are digests of more than 20 A.S.A. and A.S.T.M. specifications covering pipe, fittings and flanges.

Water Treatment Services

The industrial water engineering services offered in the fields of water procurement, treatment, usage and disposal by Hall Laboratories, Inc., are described in a new 4-page booklet entitled "Let's Consider Your Whole Water Problem." Along with an organization chart of technical staff of the consulting firm the bulletin discusses typical service problems, with illustrations showing flow schemes of water in process and disposal.

Sludge-Contact Reactors

Cochrane Corporation has prepared an attractive 16-page bulletin explaining the features and advantages of sludge-contact reactors for water processing purposes. Round and rectangular reactors are described and illustrated by section drawings. Typical applications are mentioned as well as auxiliary equipment and supplemental apparatus.

Steam Turbines

A new 12-page booklet entitled "The Terry Multistage Turbine" was recently announced by Terry Steam Turbine Co. Illustrated with photos and drawings, the bulletin gives data on casing, lagging, blades, nozzles, wheels, shafts, bearings, governors and control valves.

Fine-Screen Strainers

Yarnall-Waring Co. has issued a 6-page bulletin providing up-to-date data on Yarway screwed strainers, $^1/_4$ in. to 3 in., and expanded information on flanged strainers, $^1/_2$ in. to 5 in. Both types are available for steam service up to 600 psig, 750 F, and for cold liquids or gas up to 1000 psig.